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#258 NOVEMBER 2026

Sky at Night

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JUPITER CREATOR OF PLANETS

How were the Solar System's worlds made? A startling new study says Jupiter was the key

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SUPERNOVAE?*

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keep company
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Welcome

Could Jupiter be the reason you're reading this?

It struck me recently that one of the most astounding advances in astronomy is our ability to see alien worlds as they're being born. We can now watch planets at the earliest stages of their creation, carving out grooves in the dense dust that surrounds young stars. While we'll never witness this stage in our own Solar System, new research highlighted this month adds a fascinating dimension to the story of how the Sun's planets formed. It suggests that without Jupiter's influence, the seven other worlds we know so well – including the one we call home – might never have existed. Joseph Phelan takes up the story on **page 67**.

Billions of years later, the products of that dusty solar crucible are there for us to see. Look up at the night sky this month to watch bright Mars close in on the beacon of Jupiter. The pair put on a dramatic show, passing bright stars and joining the Moon. Pete Lawrence has the details in The Sky Guide from **page 43**.

We visit Mercury this month too: on **page 60**, Govert Schilling looks at the new mission arriving at the nearest planet to the Sun. After an eight-year voyage to slow its speed enough to enter orbit, BepiColombo's two spacecraft will spend at least a year uncovering the mysteries of this small world. Since it has been visited by only two missions before, much remains unknown, including the effects of powerful solar flares on a planet orbiting so close to its parent star.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Tuesday 17 November.

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Editorial enquiries +44 (0)117 471 4587

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Advertising enquiries +44 (0)117 476 7313

Print subscription enquiries

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Digital subscription enquiries

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Editorial enquiries

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Subscription enquiries

UK enquiries: FREEPOST OURMEDIA
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Overseas enquiries: PO Box 3320,

3 Queensbridge, Northampton, NN4 7BF, UK

Editorial enquiries

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Sky at Night – lots of ways to enjoy the night sky...



Television

Find out what *The Sky at Night* team have been exploring in recent and past episodes on **page 18**



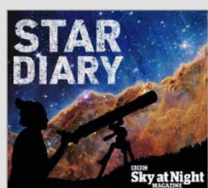
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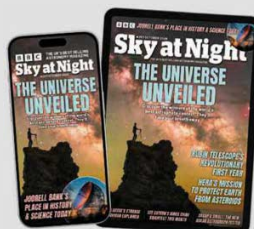
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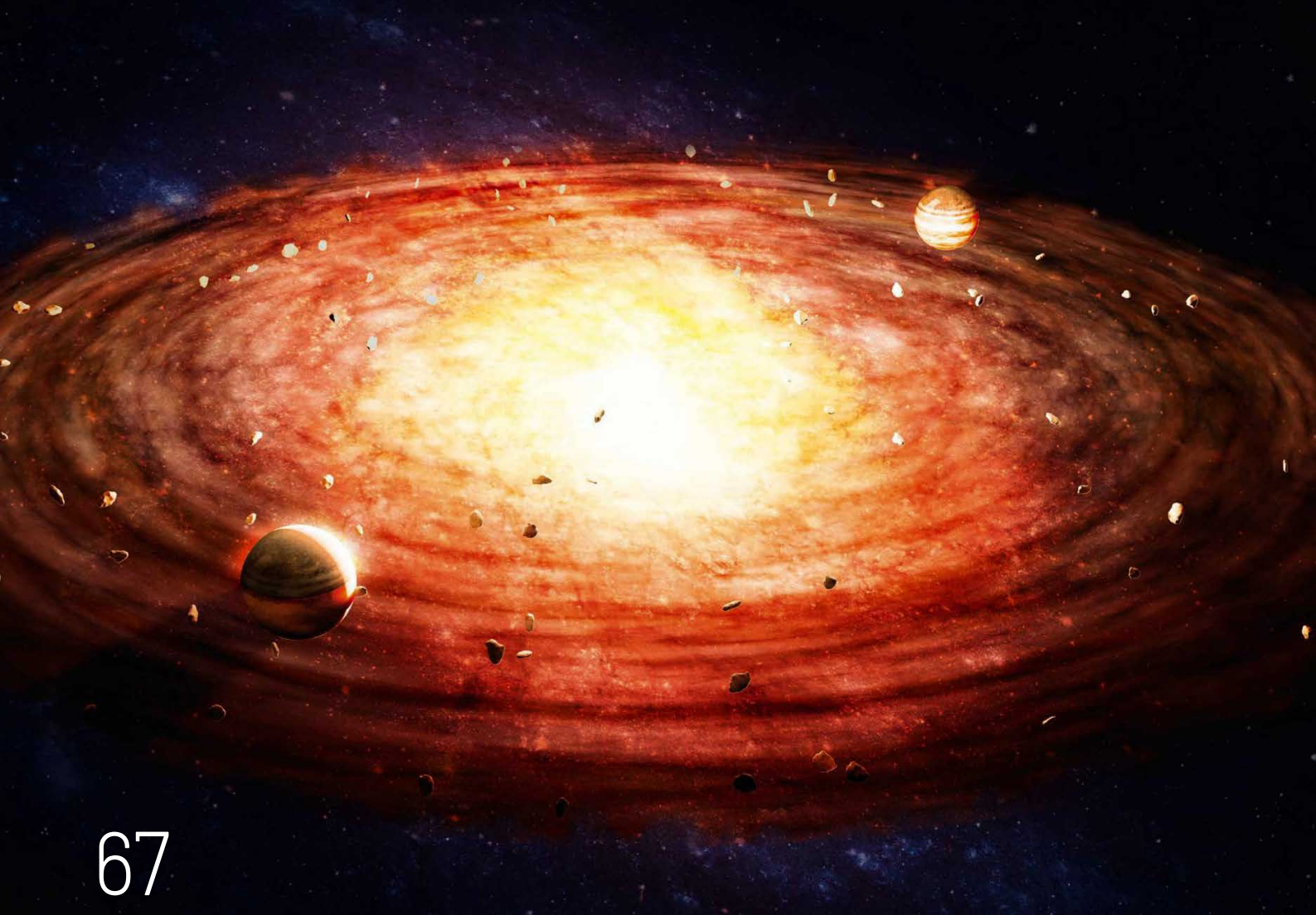
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CENTRE
PULLOUT

New to astronomy?

To get started, check out our guides and glossary at www.skyatnightmagazine.com/astronomy-for-beginners



This month's contributors

Giles Sparrow

Science writer



"Like many stargazers, I'd love to see a bright Milky Way supernova in my lifetime – but it's fascinating to discover why they're rarer than we might expect." **Giles explains why local supernovae are so elusive on page 40**

Govert Schilling

Astronomy author



"As a teenager, I took a day off from my Saturday job to watch Mercury pass in front of the Sun. So I'm really looking forward to the results from BepiColombo!" **Govert digs into the Mercury mission on page 60**

Joseph Phelan

Science journalist



"The idea that a 'planetesimal factory' once existed beyond Jupiter is a compelling one. It's always intriguing to explore the Solar System's origins." **Joseph looks at the gas giant's effect on page 67**

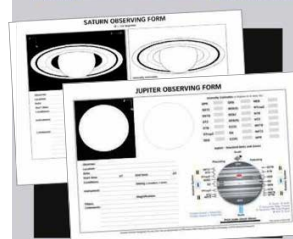
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NOVEMBER HIGHLIGHTS

Planet hunting with Roman

Eamonn Kerins reveals how the new Roman Space Telescope will uncover new worlds across our Galaxy.



Sketch and record your planetary observations

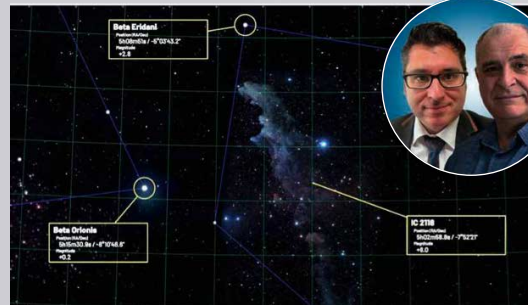
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The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.





EYE ON THE SKY

HUBBLE BUBBLE

Hubble captures a sparkling superbubble sculpted by winds and supernovae

HUBBLE SPACE TELESCOPE, 3 SEPTEMBER 2026

This spectacular Hubble image of LHA 120-N44 (N44 for short), an emission nebula in the Large Magellanic Cloud, reveals a vast shell of gas enveloping a central 'superbubble'.

The massive void at N44's heart has been carved out by the many stars seen inside. Their stellar winds, augmented by a few supernovae along the way, have cleared the centre of gas and dust, which now clumps around the bubble's perimeter, ready to coalesce into another new generation of stars. Indeed, NASA has detected over 30,000 newborn pre-main-sequence stars among the half a million or so in the region.

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△ Hear me roar

**JAMES WEBB SPACE TELESCOPE,
10 AUGUST 2026**

This new JWST image of the Lion Nebula clearly shows the 'nose' of the Lion, which is really the white dwarf star that lies at its centre. Radiation emanating from the white dwarf has sculpted the surrounding gas and dust into the nebula's distinctive leonine shape.

Old and new ▷

**JAMES WEBB SPACE TELESCOPE,
27 AUGUST 2026**

Arp 263 is an irregular galaxy located 25 million lightyears away from Earth in the constellation of Leo. Thought to be the chaotic final phase of a long-ago merger between two galaxies, its red areas are home to dense clouds of gas and dust, while the isolated areas of young star formation shine blue.



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Martian solar eclipse ▷

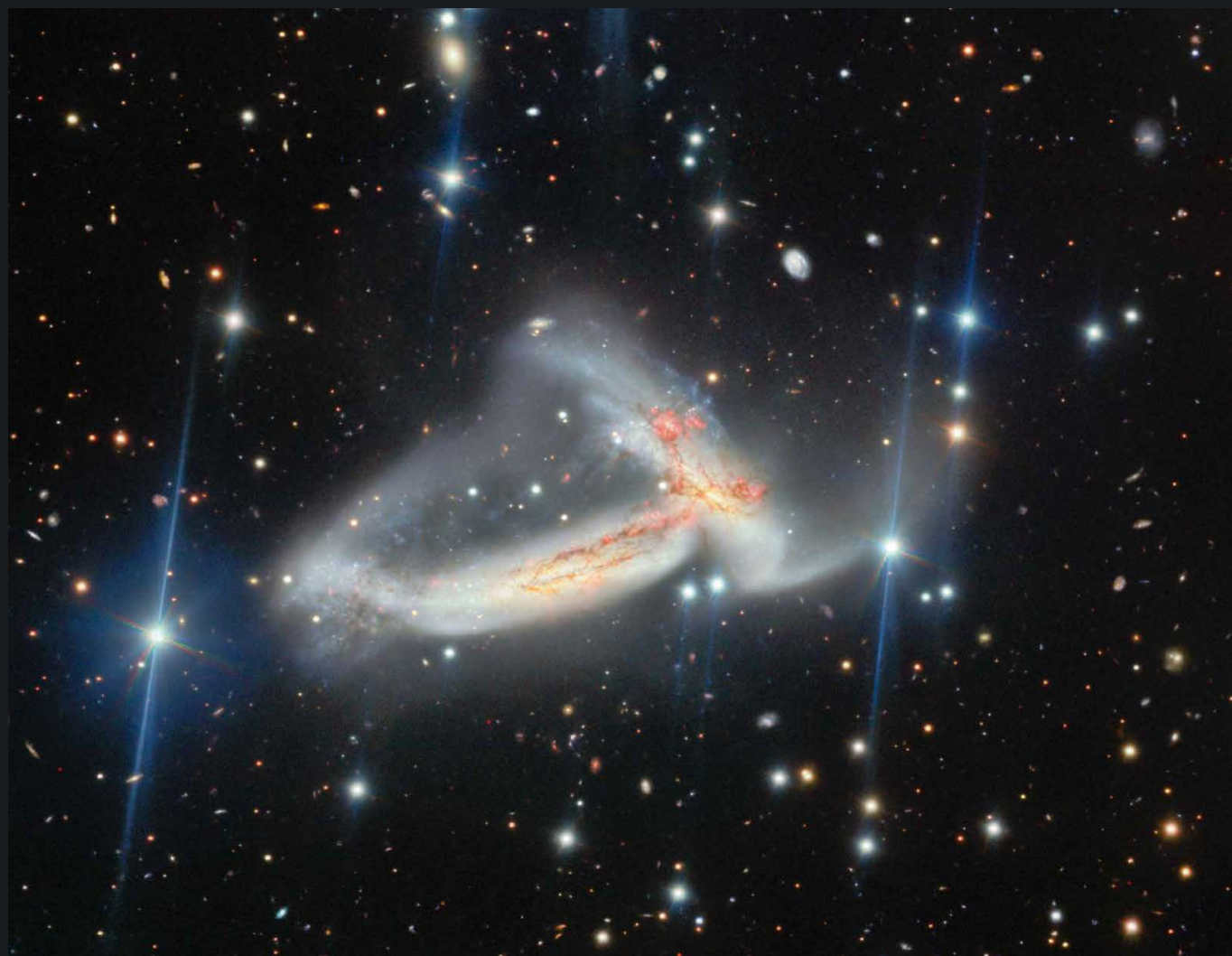
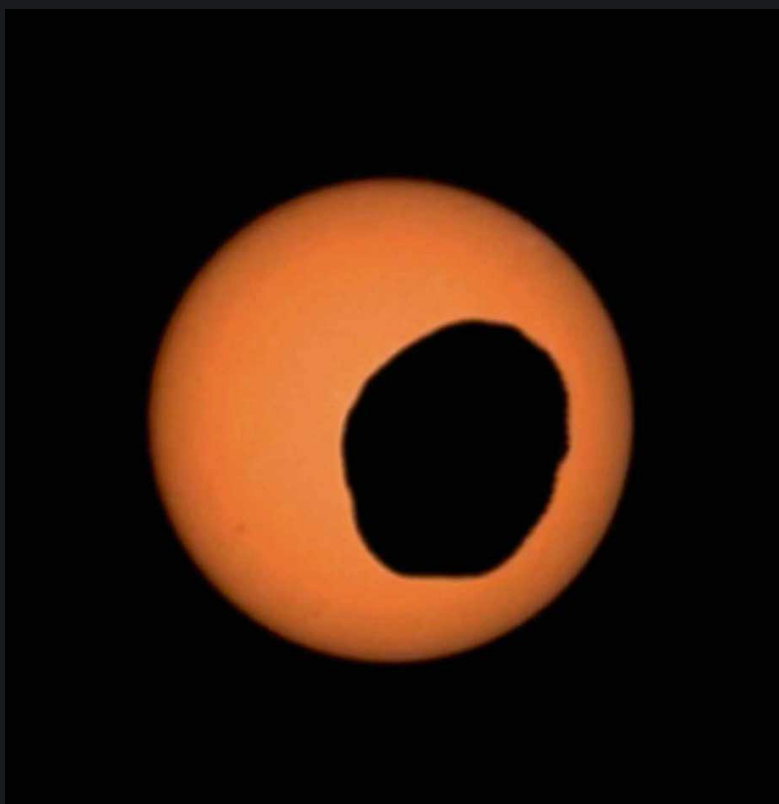
MARS PERSEVERANCE ROVER, 12 AUGUST 2026

Captured by Perseverance's Mastcam-Z camera, this image shows Martian moon Phobos transiting the Sun, as seen from the surface of the Red Planet. Phobos is slowly spiralling inwards towards Mars, so scientists hope that studying such transits will enable them to better understand its orbit.

▽ Twin spirits

GEMINI NORTH, 1 SEPTEMBER 2026

This is our closest look yet at NGC 7253, a pair of spiral galaxies that have become ensnared by each other's gravity. The system was given the Hawaiian name Nā 'Uhane Māhoe Huki Pū i ke Ola ('The Twin Spirits Pulling Together Creating Life') by students on Gemini Observatory's Project Hōkūlani internship programme.

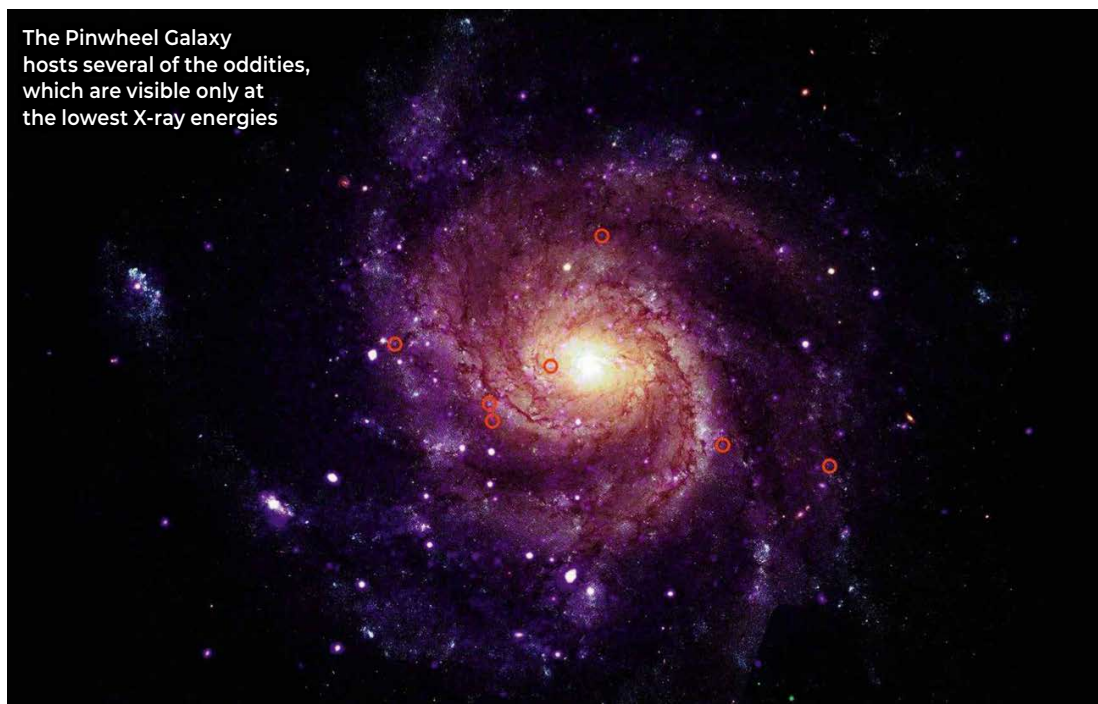


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The latest astronomy and space news, written by Jamie Middleton

BULLETIN

The Pinwheel Galaxy hosts several of the oddities, which are visible only at the lowest X-ray energies



Comment

by Chris Lintott

Dian Triani in Harvard will be looking at these new discoveries with some excitement, having led work only last year that pointed out that many galaxies show signs of harbouring excited gas, despite the absence of a nice, bright active galactic nucleus to do the job.

Objects like these seem to provide enough 'hard' or high-energy radiation to have an impact on their surroundings.

More than that, they're a useful reminder that, even in a time with new telescopes arriving rapidly, there is scientific gold hidden in the archives. With astronomers getting better at sifting through the data, who knows what might turn up next?

Chris Lintott
co-presents
The Sky at Night

New class of cosmic objects found

Mysterious hypersoft X-ray sources aren't like anything seen before

Astronomers combing through archival data from NASA's Chandra X-ray Observatory have identified a new class of cosmic objects that behave unlike anything catalogued before – and which could help resolve two long-standing mysteries in astrophysics.

The objects were uncovered in a trove of data collected by Chandra between 1999 and 2017, suggesting more may yet be found.

'Hypersoft X-ray sources' emit unusually low-energy X-rays and intense levels of ultraviolet radiation. They were identified in six galaxies, including the Andromeda and Pinwheel galaxies. In total, 84 were discovered by comparing images taken at different X-ray energies; the new objects appeared only in those taken at the lowest energies.

"We've never encountered a group of objects that act like this," says lead researcher Mustafa Muhibullah of the University of Alabama. "Of course, the next step was to try to figure out what these things are."

Researchers believe they may be binary systems in which a compact object – potentially a white dwarf, neutron star or black hole – is pulling material from a companion star. As this material falls towards the compact object, it heats up and produces radiation.

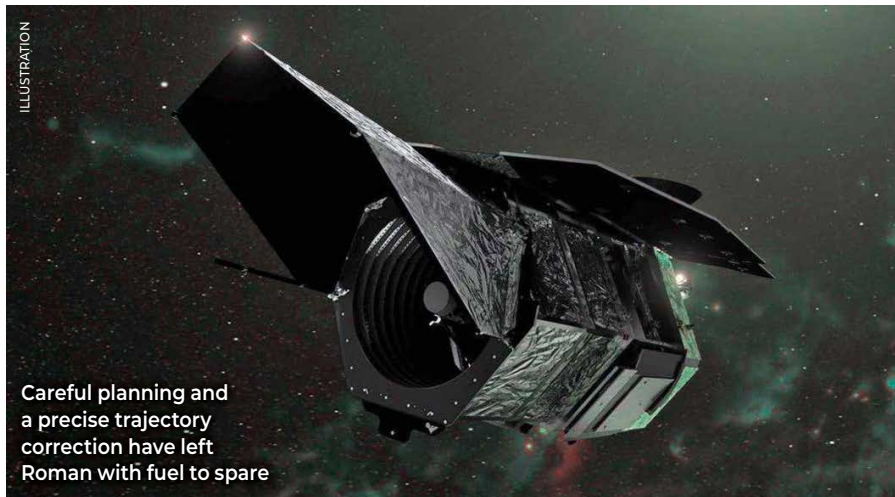
Their unusual behaviour could help solve two puzzles. The first is Type Ia supernovae, which are used to measure the Universe's expansion. The scenarios that trigger them remain uncertain; these new hypersoft X-ray sources could be a candidate. "If we could find a way to spot these Type Ia supernova explosions before they go off, that would be really important," says co-author Jimmy Irwin.

The second puzzle is the source of radiation that strips electrons from diffuse gas in and around galaxies, a process that helps shape star formation. The new objects' intense ultraviolet output may provide part of that missing radiation.

There are good reasons these objects remained hidden for so long. Low-energy X-rays are difficult to detect, while ultraviolet radiation is readily absorbed by hydrogen and helium gas between the stars. "By combing through the Chandra archive, we were able to eliminate what used to be a blind spot for telescopes," says co-author Rosanne Di Stefano. The team now hope to identify more hypersoft X-ray sources and determine what powers them.

Space telescope may have doubled its mission time

Being frugal with fuel could extend Nancy Grace Roman's operation to 22 years



NASA's brand-new Nancy Grace Roman Space Telescope could have enough fuel to extend its mission by 12 years, more than doubling its original lifetime, thanks to its lighter-than-expected launch weight and an exceptionally accurate course-correction manoeuvre.

Launched on 30 August, Roman will explore dark energy, map dark matter

and conduct a vast census of planetary systems in our Galaxy in its five-year primary mission. This was to be followed by a five-year extension, giving it a total fuel budget of 10 years. But its first major trajectory correction used less than 10 per cent of the fuel allocated for the burn.

It was carried out with more than 99 per cent accuracy, requiring about 18kg

(40lb) of propellant instead of the 200kg (441lb) that NASA had budgeted.

"As a result of exquisite planning by our orbital dynamics team, brilliant execution by the operations team, and a precise launch from SpaceX, Roman has fuel for at least 22 years of potential science operations," says Jamie Dunn, centre director at Goddard Space Flight Center.

Roman also launched considerably lighter than the conservative maximum mass used to calculate its propellant requirements. "A spacecraft's mass changes throughout the design and build process, so we base the propellant budget on a set maximum value so we won't come up short," says Alison Rao, Roman's propulsion lead at Goddard.

The projected 12-year extension also factors in fuel savings expected from an upcoming second mid-course correction, which should be minimal due to the precision of the first.

► For more on how Roman will change our view of the Universe, see page 29

Did the Sun swallow a planet?

Our star may have ingested an ancient world up to 10 times the mass of Earth

New research suggests

the Sun may have swallowed a rocky planet early in its history, leaving a detectable mark buried inside our star.

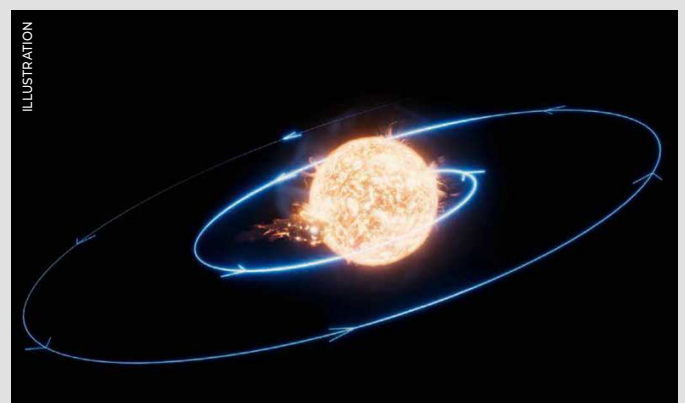
"A planet several times more massive than Earth may have fallen into the young Sun and left a lasting chemical imprint deep inside it," says researcher Professor Mutlu Yildiz, of Ege University in Turkey.

"By modelling the Sun's evolution and comparing the results with precise observations of its interior, we find that the ingestion of a super-Earth could help explain long-standing differences between standard solar models and observations,

including subtle changes in the Sun's internal structure and its depleted lithium abundance."

The research team used open-source software called MESA (Modules for Experiments in Stellar Astrophysics) to simulate the life cycles, structure and evolution of stars, modelling different types of material being added to the young Sun.

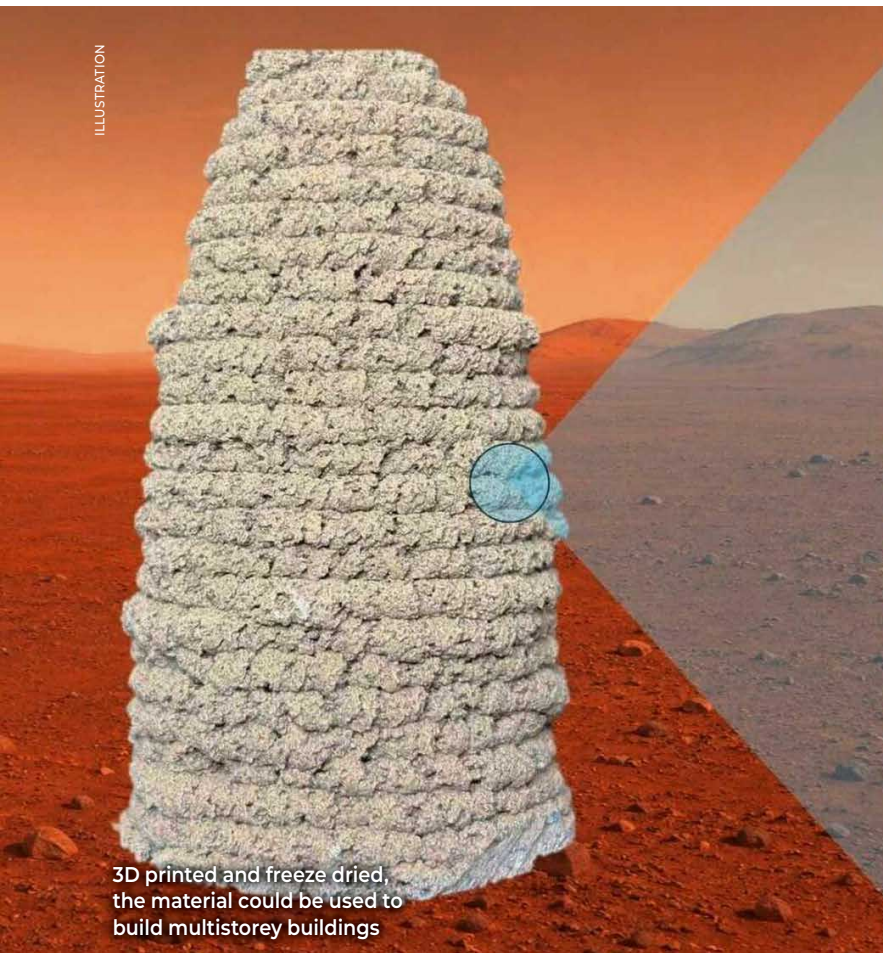
Their results point to a missing super-Earth-sized planet with a mass of around 5–10 times that of Earth. The simulations also indicate such a world could have survived its plunge through the young Sun's outer layers largely intact.



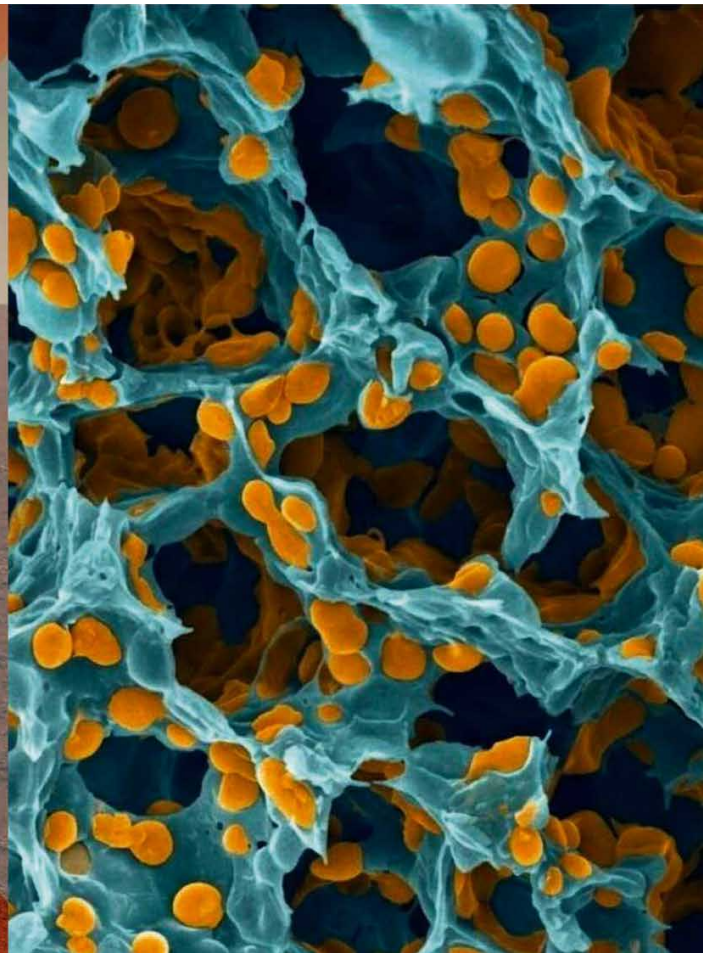
▲ If the young Sun ate a super-Earth, it could explain why our Solar System lacks the most common type of planet known

The result does not definitively prove that the Sun swallowed a planet; other explanations could also account for the discrepancies between solar models and

observations. The team's next step is to determine whether the predicted fingerprints can be independently detected through helioseismology or other observations.



3D printed and freeze dried, the material could be used to build multistorey buildings



Could yeast help build houses on Mars?

Bioengineered yeast and gelatine could bind Martian soil into a concrete-like substance

Engineers have developed a recipe for a 'living' building material, combining Martian rock, gelatine and genetically engineered yeast. It could one day be used to 3D print habitats on Mars by using the Red Planet's hostile conditions to humanity's advantage.

The material, developed at the Hong Kong University of Science and Technology, uses yeast modified to produce highly adhesive proteins, including those that mussels use to cling to rocks. The gelatine acts as a binder and provides a medium in which the yeast can grow, while the Martian soil provides the bulk and structure. Once extruded through a 3D printer, the mixture can be hardened using the freezing, low-pressure conditions found on the surface of Mars.

Rather than requiring energy-intensive heating to melt or fuse Martian rocks, the team are effectively using Mars itself as a freeze dryer. Testing the material at around -30°C (-22°F) and 0.01 Earth atmospheres of pressure, conditions similar to Mars, water in the material freezes and then changes directly from ice into vapour, leaving behind a lightweight, porous structure.

The 3D-printed domes tested so far are small at around 45mm tall and 30mm wide, but the material has a compressive strength of 10–12 megapascals, comparable to low-grade concrete.

"This is actually strong enough to build a one- or two-storey building on Earth, where gravity is three times that of Mars," says civil engineer and lead researcher Jishen Qiu. "You can probably

easily build a multistorey building on Mars with the material."

This biological approach could also support a circular economy on Mars, with settlers recovering yeast from dismantled structures and regrowing it in bioreactors. The study notes that samples can be crushed, redissolved and reprinted at least four times without any significant loss of performance.

There are major hurdles, however. The experiments were carried out under simulated conditions on Earth; researchers don't know whether the yeast could survive for long in the real Martian environment. They stress that the study is therefore not a blueprint for building the first Martian city, but a demonstration of how biology could be part of future off-world construction.

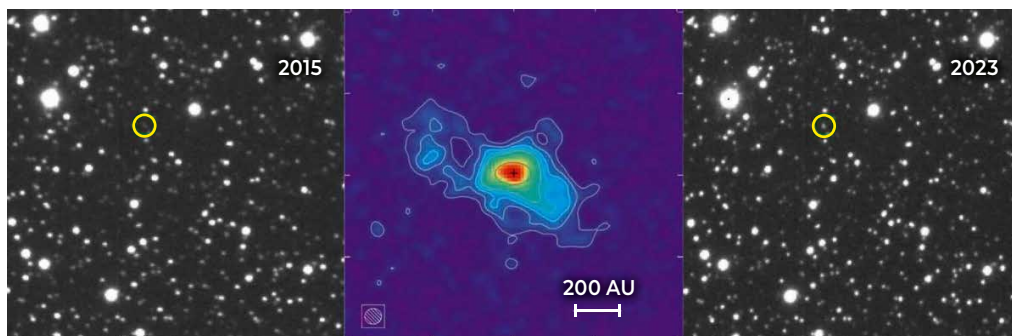
Reborn star seen racing through stellar evolution

Scientists get rare chance to witness a star's transformation on human timescales

New research has confirmed that one of the fastest-changing stars ever observed has entered a new phase of its evolution, providing a rare chance to watch a star's life unfold over a human lifetime instead of millions of years.

The star V4334 Sagittarii, known as Sakurai's Object, has become six times hotter over the past 30 years, marking one of the most rapid stellar transformations ever recorded. An international study led by researchers at the University of Manchester, UK, and Valongo Observatory, Brazil, shows that it has developed characteristics similar to a Wolf-Rayet star.

Wolf-Rayets are rare, super-hot, massive stars in a late stage of life that shed their outer hydrogen layers through fierce stellar winds.



▲ Sakurai's Object has reheated to around 30,000K since its dramatic 'rebirth' in 1996

Sakurai's Object is far less massive, but has developed a similar powerful stellar wind, placing it in a category known as [WR] stars.

Sakurai's Object was essentially 'dead' before it unexpectedly reignited in 1996, having already reached the final stages of its evolution. Scientists believe it had ended nuclear burning and begun its journey towards

becoming a white dwarf when it underwent a rare 'very late thermal pulse', the reignition of a helium layer deep within.

The event caused it to expand and cool rapidly, ejecting large amounts of material and briefly reverting to an earlier stage of life. Only one other star, V605 Aquilae, has been directly observed undergoing this type of dramatic rebirth.

"Most stars evolve so slowly that major changes take place over timescales far longer than a human lifetime," says Professor Albert Zijlstra of the Jodrell Bank Centre for Astrophysics at the University of Manchester.

"Sakurai's Object offers something far rarer. It is one of the very few stars known to have changed dramatically within just a few decades."

27 new objects beyond Neptune hold ancient clues

Hubble and JWST reveal surprisingly unaltered billion-year-old icy bodies

Some of the smallest objects in the outer Solar System appear to have preserved clues to how they formed billions of years ago, despite expectations that collisions should have altered them.

Astronomers combined observations from the Hubble Space Telescope and James Webb Space Telescope to study 27 newly discovered trans-Neptunian objects (TNOs), small, icy bodies orbiting beyond Neptune. Some are the faintest, tiniest objects ever directly observed, at just 5km (3 miles) across. The results provide a new look at planetesimals, the building blocks of planets.

They expected the smallest TNOs to show more evidence of collisions than

Researchers say the tiny trans-Neptunian objects 'remember' how they formed



larger objects. Repeated impacts should have broken up their surfaces and mixed their materials, producing different colours and compositions.

Instead, the small objects largely follow the same colour relationships seen

among much larger TNOs. Because colour provides clues to surface composition, this suggests their surfaces have changed surprisingly little. They also uncovered fewer tiny TNOs than some models of planet formation predict.

"It's really fascinating to see that the smallest objects are somehow 'remembering' and preserving the history of how they were made," says lead author Anastasia Morgan of Northern Arizona University.

The team are now planning deeper observations. Future JWST observations could search for TNOs as small as 1km (0.6 miles) across, potentially providing an even clearer picture of how the Solar System's planetary building blocks formed.

Mystery of the youngest planet ever observed

At just one million years old, the baby giant is growing far faster than models predict

Astronomers have confirmed

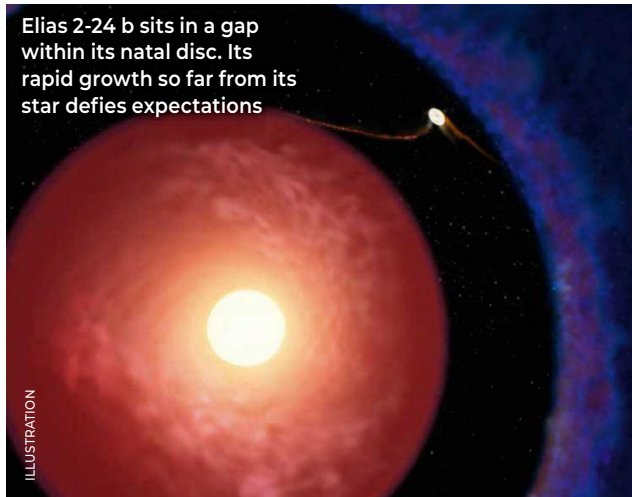
the youngest planet ever discovered – a Jupiter-mass world less than a million years old that's still growing inside the disc of gas and dust from which it formed.

Known as Elias 2-24 b, it's a giant world that orbits a star about 450 lightyears from Earth. Embedded in a protoplanetary disc, it's still gathering material, giving astronomers a chance to observe a planet as it forms.

However, according to current models, Elias 2-24 b should not have had time to grow so large at such a distance from its star: 55 times as far as Earth is from the Sun.

"Our planet-formation models already struggled to explain the previous record holders for the youngest known planets, which are all more than five million years old," says Lucas Cieza, a professor at the Instituto de Estudios Astrofísicos at Diego

Elias 2-24 b sits in a gap within its natal disc. Its rapid growth so far from its star defies expectations



Portales University, Chile, and co-author of the study. "Elias 2-24 b shows us that even our best models are still missing some important processes."

Yet despite posing a problem for existing models, Elias 2-24 b has helped confirm a key prediction about how planets form. Astronomers expect young

planets to carve gaps in the discs of gas and dust around their parent stars. Observations in 2017 from the Atacama Large Millimeter/submillimeter Array (ALMA) in Chile revealed just such a gap, and the European Southern Observatory's Very Large Telescope, also in Chile, later detected a faint point of light sitting within it.

When the authors searched Hawaii's Keck Observatory archive, they found the same faint object in observations from 2018 and 2020.

"Planets should be found within the gaps, since they are carving them," says lead author and PhD student Andrea Bernardi. "And that's exactly where we found Elias 2-24 b."

Cieza says the find marks the start of a new era: "It's incredible that with modern technology, we are actually able to see planet formation in action."

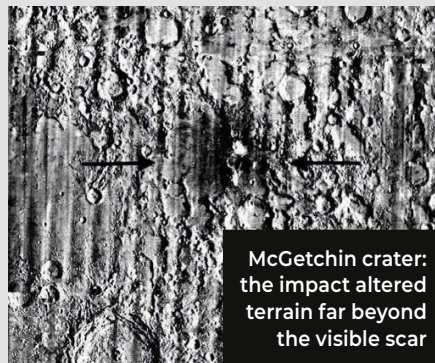
LRO explores once-in-a-century Moon crater

NASA's Lunar Reconnaissance Orbiter uncovers fresh details of two-year-old impact

A fresh analysis of the largest newly discovered natural crater in the Solar System – a 222-metre-wide (728ft) scar created when a large space rock slammed into the Moon in 2024 – has revealed that such lunar impacts do more than just make a big hole in the ground.

Named McGetchin crater, after lunar scientist Thomas McGetchin, the crater formed at some point between 11 April and 22 May 2024. Scientists estimate that a lunar impact of this size occurs only about once every 130 years.

The crater wasn't spotted until 24 October 2025, when Robert Wagner, an image-processing specialist working with NASA's Lunar Reconnaissance



Orbiter's (LRO) camera system, found it while conducting a routine check of maps of the surface.

"I just stopped, dropped everything and started looking into what that spot was," says Wagner.

LRO's Diviner thermal instrument investigated the crater's surrounding terrain. It found a cold region about 7km (4 miles) across, where the surface is around 9°C (16°F) cooler at night than nearby areas. The impact appears to have 'fluffed up' the lunar regolith, making it less dense and therefore less effective at retaining heat.

The thermal disturbance also extends far beyond the visible crater, showing that a relatively localised impact can alter the Moon over a much larger area.

The finding could prove useful for future lunar missions, helping scientists to better assess the terrain around landing sites, rover routes and other infrastructure.



Mars trades rust red
for raspberry as frost,
dust and morning light
transform the scene

The Purple Planet? Mars as you've never seen it before

Mars Express orbiter captures
the berry-toned cliffs of Thyles
Rupes during Martian spring

Mars is famous for its rusty-red landscapes, but this spectacular new image from ESA's Mars Express shows the Red Planet in an altogether different palette. Swirls of purple, pink and raspberry surround an icy cliff called Thyles Rupes at the planet's south pole, which stretches for hundreds of kilometres and rises more than a kilometre high in places.

Mars's familiar red and ochre appearance is largely caused by iron-bearing minerals that have oxidised – effectively rusting in the planet's environment. But in this view, a combination of volcanic material, frost, dust and rosy early-morning light produce its predominantly purple tones.

The darker areas are rich in minerals such as olivine and pyroxene, produced and distributed by ancient volcanic activity. Meanwhile, the pale and bluish regions are covered with carbon dioxide frost. Remarkably, some of this seasonal frost remained on the surface even though the image was taken during Martian spring.

50km

N

Our experts examine the hottest new research

CUTTING EDGE



Never mind radiation and low gravity – Mars's fine red dust may prove a more insidious risk

that astronauts may ingest around a tenth of a gram of Martian dust every day, accounting for around 90 per cent of total exposure. Inhalation is also a significant risk. The tiny size of Martian dust particles, coupled with the planet's lower gravity, mean that dust remains lofted in the air for much longer and can be breathed deep into astronauts' lungs.

Testing the toxicity

But which heavy metals are the most concerning, and how can the hazard be minimised? The researchers considered a 70kg (11-stone) adult astronaut on an 18-month surface mission, calculating the risk posed by different heavy metals, based on their concentration in Martian dust and their potency as either a toxin or carcinogen.

They found the most critical health risk is posed by chromium. Levels are around 140 times higher in Martian regolith and wind-blown dust than in Earth's crust. Without plate tectonics, this metal hasn't been transferred deeper into the Red Planet's interior. Chromium is both carcinogenic and toxic, damaging the lungs, digestive tract, liver and kidneys. Anjum and Bart identified cobalt as the second-biggest toxicity hazard, and nickel as a significant cancer risk.

The study shows just how big a threat Martian chemistry is to safe human exploration, but also that the risks can be substantially reduced through careful mission design. After astronauts return from the surface, their suits and the airlock would need thorough dust decontamination. HEPA (High-Efficiency Particulate Air) filters, already used in hospitals and factories, can remove 95 per cent of dust suspended in the air.

But even with these safeguards, they calculate chromium levels inside the habitat would remain problematically high. Astronauts would also need to take medicinal countermeasures, including high doses of vitamin C to combat the effects.

Mars is an alien planet indeed, a place where even the soil is poisonous. But it seems fitting that part of the solution may lie with vitamin C: it protected seafarers centuries ago from scurvy, and could safeguard future space explorers too.

Will the first astronauts on Mars be poisoned by Martian soil?

Escaping the Red Planet's toxic dust will be vital if we're ever to live there

As space exploration moves towards the first crewed missions to Mars, several hazards to astronaut health need to be considered. Cosmic radiation – high-energy particles spat out by the Sun – is being intensively studied, along with the effects of Mars's reduced gravity. But, according to Mavia Anjum and Gwendolyn Bart from the department of physics at the University of Idaho, another crucial hazard has received far less attention: the toxicity of the Martian surface itself.

Mars has a very different geological history to Earth, and the absence of processes such as plate tectonics means certain metals are present in much higher concentrations. Many heavy metals are harmful through chemical toxicity or by causing cancer. Lead poisoning, for example, damages the brain and nerves, digestive tract and kidneys.

Anjum and Bart argue that Martian dust, such as that brought into the airlock on astronauts' spacesuits, can disperse and contaminate surfaces throughout the habitat. Once the dust is inside, astronauts can be exposed via three main routes: eating, inhaling or direct skin contact. They estimate

"The most critical health risk is posed by chromium. Levels are 140 times higher in Martian regolith and wind-blown dust than in Earth's crust"



Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Geochemical Hazard Assessment of Martian Regolith for Future Human Exploration* by Mavia Anjum and Gwendolyn D Bart **Read it online at:** arxiv.org/abs/2608.28805

Have we found a new type of galaxy?

Isolated dwarf galaxy with surprisingly few older stars may be a 'late arrival'

You'd be forgiven for thinking all the astronomical action these days is on the cosmic frontier, as new telescopes and instruments peer at the dim and distant Universe. Yet one of the joys of the subject today is that we can still be surprised by objects closer to home.

Take the galaxy KKR 18. This dwarf system, first identified in 1999, sits around 30 million lightyears from the Milky Way. While most of our Galaxy's neighbours lie in a 'local sheet', stretching between us and the centre of the neighbouring Virgo Cluster, KKR 18 sits off on its own, above the bulk of nearby galaxies in a nearly empty region known as the Local Void. That makes it an interesting case study for seeing how galaxies evolve when left to their own devices, without disruption from the normal hurly-burly of mergers and interactions.

Now new research by an international team, led by Brent Tully of the University of Hawaii, has used the Hubble Space Telescope to take a close look at KKR 18's stars for the first time, supplemented by spectroscopic observations from a large ground-based telescope.

The Hubble image shows a diffuse cloud of stars looking more like a cluster than a galaxy. Most are blue or white, but a few red stars are scattered across the scene too. However, compared with similar galaxies, KKR 18 is strikingly devoid of red giant stars, with far fewer than we would expect.

Missing red giants

When the colours of stellar populations in dwarf galaxies are plotted on a graph, we normally see a 'red giant branch' – indeed, it's usually the most obvious feature. But it's hard to pick out in KKR 18, despite the substantial number of bright blue stars. Explaining how these form without also producing a bright set of red giants is the task the researchers set themselves.

Their solution is to assume that this particular dwarf galaxy has a highly unusual history. They



Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

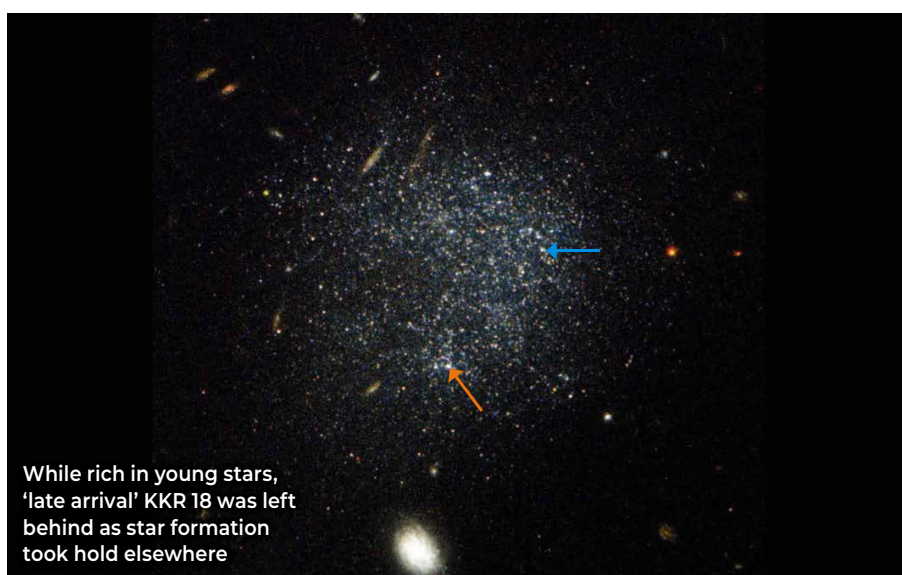
"Hubble's image shows a diffuse cloud of stars. However, compared with similar galaxies, KKR 18 is strikingly devoid of red giant stars"

can see in its stellar population plenty of signs of substantial recent star formation taking place between roughly 100 million and 20 million years ago, producing those bright, blue young stars. There is, though, very little evidence – from either Hubble or ground-based spectroscopy – of older stars. The team proposes that this is a novel example of a new kind of galaxy: a 'late arrival' galaxy – not just young, but left behind as star formation got started everywhere else.

Such galaxies are seen in at least one set of cosmological simulations, where an initially low mass prevents gas clumping and cooling, the first step to forming stars. As they accrete more matter over time, their gravitational potential grows, and star formation can switch on.

But even these simulations don't see this happening for systems of the mass of KKR 18. That discrepancy looks worse if the three other nearby systems the researchers suspect are similar are also members of this newly named class.

Intriguing. But it remains possible that there are more faint red giants hiding among the galaxy's stars. If so, deep imaging with JWST or with the forthcoming Extremely Large Telescope will reveal them. It's a useful reminder that, as well as staring at the distant Universe, these facilities will do well to take a close look at our nearest neighbours.



While rich in young stars, 'late arrival' KKR 18 was left behind as star formation took hold elsewhere

Chris Lintott was reading... *KKR 18: A Late Arrival Galaxy?*
by R Brent Tully, Valentina E Karachentseva et al.
Read it online at: arxiv.org/abs/2609.04437

Behind the scenes of *The Sky at Night* TV show

INSIDE THE SKY AT NIGHT

From academics to engineers, space science depends on thousands of people, each bringing different strengths



George Dransfield explores how differently wired minds are pushing astronomy forwards

What were you doing on the morning of 30 August? I hope, like me, you made plans to watch the launch of the Nancy Grace Roman Space Telescope (known as Roman for short). But I hope that, unlike me, you weren't thwarted by a two-year-old who instead wanted you to devote your full attention to building a train track. Despite not seeing it with my own eyes, I know the launch was a resounding success and Roman is making good progress on its 100-day journey to its home in orbit. We can now look forward to the amazing science to come – from dark energy to exoplanets – in the next decade.

These days, telescope launches get me thinking about the people behind them. Years ago, I met Professor Dave Latham, director of science for TESS, the Transiting Exoplanet Survey Satellite, at Harvard University. Chatting in his office, he told me about the journey he and countless others had gone on to get the now iconic TESS mission to launch. Years of preparing and submitting proposals, followed by design, development and deployment.



George Dransfield is an exoplanet huntress at the University of Oxford and a presenter on *The Sky at Night*

And the work doesn't end there. Once the mission is producing data, hundreds of academics pore over it to extract the scientific results we all crave. A lot of individual brains are needed to get us from "great idea for a space telescope" all the way to "here's a cool new planet!". Roman will be no different.

Perhaps I also have brains on the brain because of October's episode of *The Sky at Night*. In 'Space for Different Perspectives', my co-presenter Maggie Aderin chats to folks in and around astronomy who, like her, are dyslexic, about how their neurodivergence shapes the way they do science.

I'm not dyslexic myself, so I can't speak to that experience, but another type of neurodivergence is very close to home in my little corner of astronomy. A close friend of mine, Ellie (not her real name), is

"A lot of brains are needed to get from 'great idea for a telescope' to 'here's a cool new planet!'"

an exoplanet researcher with ADHD. Academia can be a genuinely fascinating, and often profoundly frustrating, place to have an ADHD brain.

Beyond the stereotype

I think people picture academics as constantly doing science. That's the sexy part, after all, and all that's ever shown in popular culture. Take *Don't Look Up*, the awesome Netflix movie where a comet is on a collision course with Earth. What we didn't see was Jennifer Lawrence's character doing her expenses after she got back from the observatory. It's literally the only unrealistic thing about that movie because, sadly, admin is as much a part of everyday life for astrophysics academics as coding.

For Ellie, it's often not the difficulty of the task that matters. Reading papers can take a huge amount of mental work, regardless of how challenging or dense the science is. If a task isn't stimulating enough, it's a monumental struggle to get her brain to engage. She tells me, "sometimes, it takes a lot of mental effort to start something I actually enjoy".

Part of the problem can be executive dysfunction, the unbelievably frustrating experience of knowing a thing needs to be done, *wanting* to do the thing, and still finding it nigh on impossible to make your brain do said thing. Weave in a deadline and the problem can become even worse – although sometimes it can help too, says Ellie: "I need the threat of disappointing someone other than myself."

But this isn't the full story. Just because someone with ADHD struggles to direct their attention to an under-stimulating task, that certainly doesn't mean they can't concentrate. Ellie experiences hyperfocus – meetings with collaborators leave her bursting with

How to watch

Catch the show on the

BBC
iPLAYER

▼ *Don't Look Up*: plenty of killer comet drama, none of the paperwork



ideas, so much so that she's absorbed in her work for the rest of the day. In fact, anyone who's shared an office with Ellie will be very familiar with seeing her, headphones on, so deeply engrossed in her work that we have to wave a hand in front of her face to get her attention!

Of course, there is no one way to experience ADHD, just like there is no single way to experience dyslexia. But chatting to Ellie reminded me how much science benefits from people who think and work differently. The Roman Space Telescope is the shiny new instrument of the moment, and we'll need hundreds of different brains looking at its data, asking different questions and spotting different things, to uncover everything it has to show us. 🌌



Observatories on La Palma, Spain, are among the best on Earth

La Palma – Gateway to the Universe

As a new array of telescopes is inaugurated on the Canary Island of La Palma, *The Sky at Night* visits the Roque de los Muchachos Observatory, one of the best places on Earth for astronomy. The team discover how it's unlocking the secrets of the cosmos, from dwarf planets in the outer Solar System to the nature of dark matter.

BBC Four, 9 November, 10pm (first repeat will be on **BBC** Four, 11 November, 00:30am)

Check www.bbc.co.uk/skyatnight for more up-to-date information

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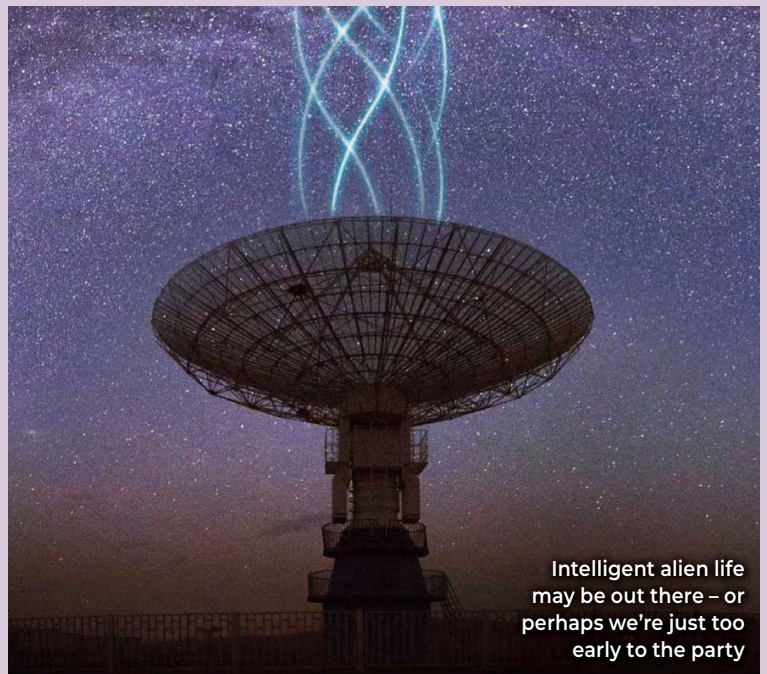
ET wasn't built in a day

Thank you for covering the Fermi paradox (Explainer, October issue). My personal answer to it is based on the glacial pace at which the Universe has developed. In the beginning, there was only hydrogen and helium. It took time for stars to develop, and more time for the elements needed to make planets appear. Aeons passed while those stars aged and became supernovae, seeding the gas clouds with the astronomical metals needed to form planets at distinctly sub-light speeds.

Once these new bodies have formed, more epochs will pass as life develops and evolves. The only planet we currently know of that hosts 'intelligent' life took 4.5 billion years from its formation to develop it, about one third of the age of the Universe. I believe that we are just one of the first. I'm sure other life forms are evolving elsewhere and will appear to us shortly – that is to say, in the next two to three billion years!

Michael Haigh, Hebden Bridge, UK

Thank you for your insight, Michael. What a great responsibility it would be to be among the first examples of intelligent life the Universe has produced. – **Ed.**



HONGLOUWAWA, GETTY



Instagram



soumyadeepmukherjeephotos

• 17 September

Lunar occultation of Venus.

These are the moments when you don't keep an eye on your watch! I was switching between naked-eye view, smart telescope and live view on the DSLR. How exciting when Venus started peeking beyond the lunar limb. Otherworldly. [@bbcskyatnightmag](https://www.instagram.com/soumyadeepmukherjeephotos)



Nice work! Gray built one of the many DIY projects on our website

Dob satisfaction

I built the platform described in Mark Parrish's article ('Build a Dobsonian equatorial platform', www.skyatnightmagazine.com). I would like to thank Mr Parrish for writing and illustrating the article, and sharing his data files for the project. The design is smart and I would not have been able to do something similar on my own.

Gray Chang, California, USA

Probe theory update

I read your article concerning my paper ('Japan is chasing an asteroid, but is it really following a dead probe?', Cutting Edge, August) with great interest. Firstly, thank you so much for covering it. I was relieved that you captured all the salient points very clearly and accurately. I am more of an astrodynamist than an astronomer, so I must defer to the experts when they argue that the 'dark comet' 1998 KY₂₆ is 'water-rich'.

I have added two new sections to my paper since you published your article, which are a qualitative analysis of how solar radiation pressure would affect non-gravitational acceleration of the object, based on some assumptions as to its general shape. Previously it had been argued that these effects contradict the notion that 1998 KY₂₆ could be a spacecraft. But the new analysis finds ►

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Editor Chris Bramley
Content Editor Iain Todd
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Reviews Editor Gemma Kerr

CONTRIBUTORS

Anthony Chambers, Brian Clegg, Yvette Cook, Lewis Dartnell, Glenn Dawes, Russell Deeks, George Dransfield, Ben Evans, Rick Galmack, Caroline Harper, Andrea Henderson de la Fuente, Tim Jardine, Pete Lawrence, Chris Lintott, Mary McIntyre, Laura Nuttall, Ivana Peranic, Joseph Phelan, Govert Schilling, Giles Sparrow, Steve Tonkin, Emily Winterburn

ADVERTISING SALES

Senior Commercial Media Manager Rebecca Janyshiwskyj
Rebecca.Janyshiwskyj@ourmedia.co.uk
Media Sales Executive Antony Jago
+44 (0)117 476 7314, Antony.Jago@ourmedia.co.uk
Inserts Laurence Robertson +353 (0)87 690 2208

CONTENT OPERATIONS

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Content Operations Coordinator Lauren Morris
Head of Operations Jessica Mills
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SVP Global Licensing Stephen Davies
Global Director, Magazines Mandy Thwaites
UK.Publishing@bbc.com; www.bbcstudios.com

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41,593 (Jan-Dec 2025)

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ISSN 1745-9869

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► that it is in complete harmony with this possibility. Thanks again for your well-written article, and I look forward to more of them.

Adam Hibberd, Hibberd Astronautics Ltd, UK

Giant origins

I've just watched the August episode of *The Sky at Night* (www.bbc.co.uk/iplayer), hosted by Chris Lintott, about the JWST discovery of little red dots, which turned out to be supermassive black holes. The theory goes that they formed without stellar collapse, from gas and hydrogen filaments, through mergers with other black holes, and collapsed under gravity.

I have an alternate theory, that the little red dots could form from the collapse of a giant star after it has run out of nuclear fuel for fusion. In the early Universe, hydrogen and helium clouds eventually formed as the hot, dense quark-gluon plasma cooled and expanded. The black holes would have had a lot of gaseous material to feed off and would have grown to a large size.

Lucy Beighton, West Sussex, UK

Living on the edge

Because I'm in Belem, Brazil, one degree south of the equator, and catch only edges of the Northern and Southern skies, it's hard to find a good star map. On the upside, the Moon is often spectacular, as is Venus and Jupiter. This photo (right)

SOCIETY IN FOCUS

Breckland Astronomical Society is a registered charity devoted to encouraging the public to look up and feel inspired. We're based beneath the dark Norfolk skies in the charming village of Great Ellingham, a designated Dark Sky Discovery Site where the Milky Way is still a regular visitor.

We meet each Tuesday at our domed observatory. Members observe through our computer-controlled 20-inch scope, while others set up instruments on the patio in optimistic negotiation with the British weather. When clouds prevail, we revert to conversation and coffee.

Through the main telescope, members have even observed an 11-billion-lightyear-distant gravitationally lensed quasar visually – a reminder of what clear skies and steady patience can reveal.

On the second Friday of each month, we host talks for the public at the

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M.Wilson_Astrophotography

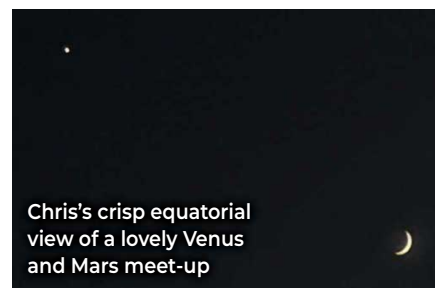
@mwilsonastro • 29 August

Woke up early, not expecting to see the lunar eclipse. Was surprised when there was a very brief break in the clouds. These were the best shots I got. #lunareclipse2026 @skyatnightmag



was taken with an iPhone 15, showing Venus catching Mars. I'm trying to work out how to ship my 8-inch telescope here from the UK (not easy). But I do miss the Northern and Southern skies.

Chris Strike, Belem, Brazil



Chris's crisp equatorial view of a lovely Venus and Mars meet-up



recreation centre, welcoming guest speakers on a wide range of subjects, with observing afterwards. The final Friday is our popular open evening, when visitors of all ages join us under the dome. We welcome Scouts and local community groups throughout the year.

Now in our 26th year, Breckland Astronomical Society continues to thrive, thanks to the enthusiasm and dedication of our volunteers.

Keith Fowler, treasurer

► www.brecklandastro.org.uk

WAITING HOURS FOR THAT ONE GLIMPSE



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FIELD OF VIEW

Why dark matter still matters – even if we never find it

Whether it's a weird form of gravity or an as-yet unseen particle, the dark matter mystery still demands an explanation, says **Brian Clegg**

Astronomers can be more than a little eccentric when naming things. Normal people know that metals are elements (or mixtures of elements) that are highly conductive, shiny, malleable and mostly solid at room temperature. Astronomers tell us every element except hydrogen and helium is a metal.

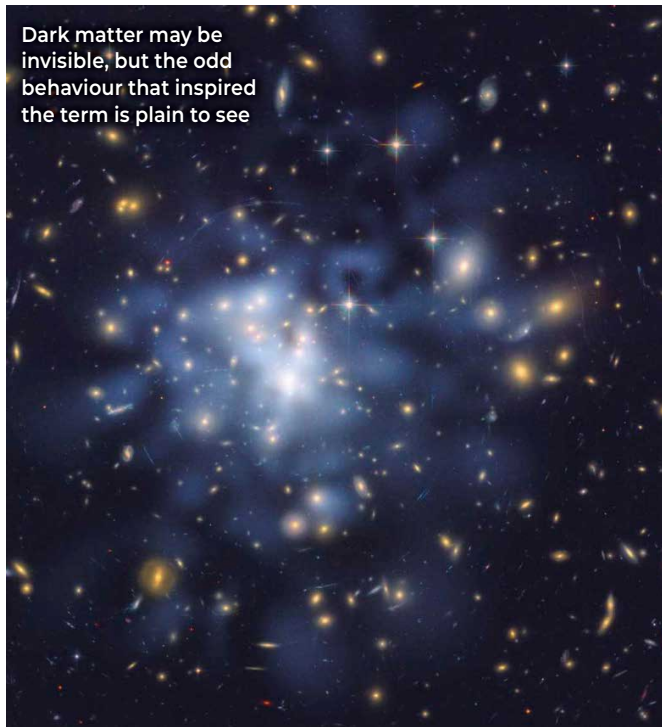
I suppose, then, it's not entirely surprising that when in 1933 Swiss astronomer Fritz Zwicky noticed that galaxies within the Coma Cluster were moving too quickly for the cluster to hold together, he blamed this behaviour on something he called 'dunkle Materie', a German term that translates as 'dark matter'.

The cluster's rotation resembled an out-of-control potter's wheel. Spin the wheel too fast and the force keeping the pot in place is overcome: the clay flies off. Similarly, though the galaxies in the cluster are held together by gravity, if the cluster rotates too quickly, they should fly out like sparks from a pinwheel. Arguably, Zwicky should have called this effect 'super sticky' or 'gravity plus', but he went with dark matter.

The reason for the name is that Zwicky argued that there must be far more stuff in the cluster than we could observe. The only way the cluster could stay together, he thought, was if there were vast amounts of unobserved matter, magnifying the gravitational attraction.

Perhaps surprisingly, Zwicky's observation was largely ignored. However, in the early 1970s, American astronomer Vera Rubin noted a related oddity in individual galaxies. Because of the nature of rotation in loosely connected bodies, like stars in a galaxy, you would expect stars towards the edge to travel around

Dark matter may be invisible, but the odd behaviour that inspired the term is plain to see



slower than many of those closer to the centre. In reality, the rotation speed was closer to constant.

This would happen if there were a lot of matter distributed around the edge of the galaxy in a spherical configuration known as a halo. But that should be obvious to astronomers – and it wasn't. Picking up Zwicky's term, a theory was developed that there was a special kind of matter, which has mass but does not interact electromagnetically. This made it transparent rather than dark, but the name stuck.

Since the theory was proposed, many experiments have been run to detect dark matter particles. This may seem impossible, but we

can successfully detect neutrinos which are also electromagnetically transparent. (For a brief time, some thought dark matter was neutrinos, but their behaviour is inconsistent.) Unfortunately, not a single particle has been detected.

It's entirely possible that this is because dark matter particles don't exist. An alternative theory suggests that the effect results from gravity acting differently on the scale of galaxies. Admittedly, there are some galaxies where such modified gravity theories fail to explain what is observed. However, there are significantly more examples where modified gravity theories provide a better explanation than particle-based models.

Personally, I would not be surprised if a modified gravity theory is incorporated into our understanding, but this kind of change takes time. No matter the outcome, though, we won't lose that label. Whatever causes the dark matter effect, it's real – and it will always matter. 



Brian Clegg is an award-winning science writer with over 50 books in print, including *Dark Matter* and *Dark Energy*. Find out more at www.brianclegg.net

Glow-up



With a JJ04 movement capable of precisely plotting each phase of the moon for 128 years, the C1 Moonglow has always had allure. Now, it exerts an even greater gravitational pull. The twin Globolight orbs, which wax and wane across the starry, sapphire dial are more three-dimensional. And, instead of glowing green, they gleam a cool, bright blue - thanks to souped-up Super-LumiNova. (Which also lights up its orbiting date wheel, for truly stellar nocturnal legibility.) Other lustrous features include a 40.5mm LightCatcher™ case, polished lug facets and optional five-link Consort™ bracelet. Even its price is illuminating: from just £2,095 on leather.

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The Nancy Grace Roman Space Telescope *gets to work*

Delivered early and under budget, NASA's newest observatory promises Hubble-quality views across vast swathes of sky. **Caroline Harper** explores how Roman is built to do more science, faster

ILLUSTRATION: TELESCOPE: NASA GODDARD SPACE FLIGHT CENTER
SCIENTIFIC VISUALIZATION STUDIO | BACKGROUND: JVP/PHOTO, ALAMY

The whole Eagle Nebula vs the Pillars: Roman's field of view is 100 times wider than Hubble's



HUBBLE
FIELD OF VIEW

NANCY GRACE ROMAN TELESCOPE
FIELD OF VIEW

What could dark matter be made of? How is dark energy driving the expansion of the Universe? Is it a constant force, or changing over time? Are alien worlds and Solar Systems like ours common in the Galaxy, or are we unique? NASA's new flagship observatory, the Nancy Grace Roman Space Telescope, is designed to answer these questions and more.

Launched at the end of August, Roman builds on the heritage of the Hubble and James Webb Space Telescopes and will yield a staggering 1.4 terabytes of data every day. Observing a billion galaxies, tens of billions of stars and an expected 100,000 new exoplanets during its five-year mission, it will provide a wealth of material for cosmologists, physicists, astronomers and planetary scientists. In fact, it's being hailed as the most efficient space telescope ever. But what exactly does that mean?

High precision, big scale

We might imagine that the highest-performing observatory needs the biggest mirror. At 2.4 metres (7.9ft) in diameter, Roman's mirror is no bigger than Hubble's, and it has a similar resolution. But it combines this with an enormous 300-megapixel camera, the Wide Field Instrument (WFI), optimised for near-infrared light and with a field of view 100 times wider than Hubble's.

This means it can produce pictures on a par with Hubble's iconic images, while surveying the sky a thousand times faster; what Roman observes in one month would take Hubble decades.

It's this that sets it apart. Senior project scientist Dr Julie McEnery at NASA's Goddard Space Flight Center sums it up: "Roman combines exquisite performance and sensitivity with the ability to cover



▲ Its main mirror is no bigger than Hubble's, but its enormous camera puts Roman in a different league

large regions of the sky quickly. This means we will get to view the Universe in a whole new way."

How is this achieved? Traditional telescopes direct light in a narrow beam onto a central point, so images are sharpest in the centre. Roman's optical system focuses light into a wide ring around the central point instead, and the camera's 18 detectors are organised into an arch to line up precisely with this large focal ring. This innovative design enables crisp images together with panoramic views.

Also critical are extremely stable optics to make precise cosmological measurements and images – a hundred times more stable than Hubble's. The primary mirror is made of ultra-low-expansion glass, and advanced engineering techniques mean it's 80 per cent lighter than Hubble's but just as rigid. The carbon composite framework around it has also been specially engineered for optical stability, and

How Roman got ahead

New space missions rarely stay on schedule. So how did Roman launch nine months early?

Named after Nancy Grace Roman, NASA's first chief of astronomy and the 'Mother of Hubble', the Roman observatory was breaking efficiency records even before launch.

Its development, led by NASA's Goddard Space Flight Center, came in under budget, at around £3.2 billion (\$4.3 billion) for the development, launch and five-year primary mission. It was ready for launch nine months early too – no mean feat for a mission with such lofty scientific ambitions and technological challenges.

This unusual outcome was partly because Roman was able to repurpose a primary mirror donated to NASA in 2012 by the US National Reconnaissance Office, drastically reducing the mirror

design and testing phases. But that's not the whole story.

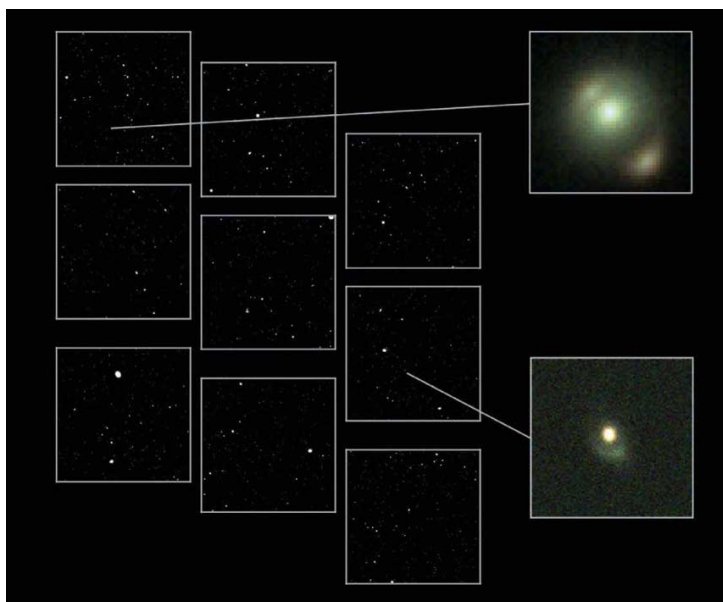
The spacecraft and instruments were built and tested in parallel to avoid bottlenecks in the schedule. The assembly and environmental testing were fast-tracked. The Science Operations and Support Centres at the Space Telescope Science Institute and CalTech also passed their readiness reviews early. Altogether, a core team of over 1,000 scientists and engineers worked around the clock, using experience gained from previous missions and pushing it to the limit to make Roman a reality.

► A monumental engineering effort and a donated mirror helped Roman reach the launchpad ahead of its 2027 deadline



there's a state-of-the-art temperature-sensing and control system.

One of Roman's main tasks is to study dark matter and dark energy. We've known for decades that these mysterious, invisible components make up 95 per cent of the Universe, but we still don't know what they are. We do know dark matter causes 'normal' matter (the galaxies, stars and planets we can see) to cluster together, while dark energy is driving the Universe apart. Roman will use a technique called weak gravitational lensing, where the mass of a galaxy in the observatory's foreground stretches light from more distant galaxies, acting like a lens and producing subtle distortions. This allows researchers to calculate the amount of 'normal' matter and invisible dark matter that is present.



▲ How lensing distorts galaxies, allowing Roman to detect dark matter's influence

came together over time will tell us more about dark matter. If it's made of heavy, slow-moving particles, 'normal' material should clump readily; if it's lighter particles, galaxies should take longer to form.

And what about dark energy? Roman's WFI will survey large areas repeatedly, examining how the distribution of normal and dark matter in galaxies changed throughout history, and using measurements of thousands of distant supernovae to plot how the rate of cosmic expansion

has changed through time. This will provide clues about the nature of dark energy. It's also critical to understanding the origins of the Universe – and what will happen in the future.

Roman's other speciality is exoplanets. Most alien worlds found so far were discovered using the ►

From dark matter to new worlds

From its orbit around the L2 Lagrange Point, 1.5 million kilometres (930,000 miles) from Earth, Roman will survey millions of galaxies and galaxy clusters using this technique, effectively looking back billions of years at some of the oldest cosmic structures, to study how they formed under the influence of dark matter. The way large structures

“Roman will look at some of the oldest cosmic structures, to study how they formed under the influence of dark matter”

DATA SENT TO EARTH Hubble vs JWST vs Nancy Grace Roman



Hubble

2.7 gigabytes
per day



JWST

58 gigabytes
per day



Nancy Grace
Roman

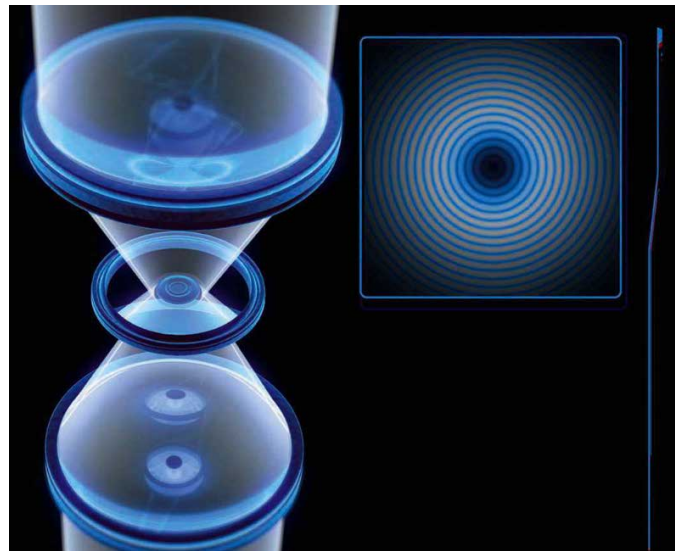
1,375 gigabytes per day

TOTAL DATA COLLECTED

Hubble
172 terabytes
(archive 1990–2020)

JWST
100 terabytes
(five-year primary
mission, projected)

Roman
20,000 terabytes (20 petabytes)
(five-year primary mission, projected)



► transit method (looking for tiny, regular dips in light from the parent star as the planet transits in front). This detects massive planets orbiting very close to their parent star – often even closer than Mercury is to our Sun – but struggles to spot smaller planets in wider orbits, like Earth.

Roman will detect many new exoplanets using transits, but will also use gravitational microlensing to survey hundreds of millions of stars in the densely packed centre of our Galaxy. Microlensing is much better at finding smaller planets orbiting farther from their stars, in the habitable zone and beyond, and is expected to reveal thousands of otherwise invisible exoplanets. This could include worlds very like most of the planets in our Solar System. It might also detect some that are completely different from anything we have known.

Turning down the stars

We won't just detect new exoplanets with Roman. We'll be imaging some of them directly. This is incredibly difficult – the few exoplanets we've photographed have mostly been enormous 'super-Jupiters', far bigger than anything in our Solar System, very young and still glowing hot. Smaller,

▲ Left: simulated image of how the centre of our Galaxy will appear to Roman

Right: flexible mirrors in Roman's coronagraph block out direct starlight, allowing dim planets to shine

colder planets simply don't reflect enough light. Those alien planets we've imaged so far also orbit far from their stars, many times the Sun–Earth distance. Any closer and even our best instruments can't distinguish light from the planet against the star's glare. Until now.

Roman's advanced coronagraph instrument changes this. Designed and built by NASA's Jet Propulsion Laboratory, it uses specialised sensors, masks and self-adjusting mirrors to correct optical distortions and cancel out glare in real time. It's the first time a coronagraph with active adaptive optics like this has been flown in space, and it will greatly improve the contrast. We'll be able to pick out older, colder planets 100 million times fainter than their star, down to the size of Jupiter. Suppressing dazzling starlight will allow us to photograph exoplanets orbiting closer to their star than ever before, in both visible and near-infrared light.

The demonstration of this cutting-edge coronagraph and its adaptive optics is essential to pave the way for even more sophisticated telescopes of the future. This includes NASA's Habitable Worlds Observatory, planned for launch in the 2040s, which will take these technological advances even further.

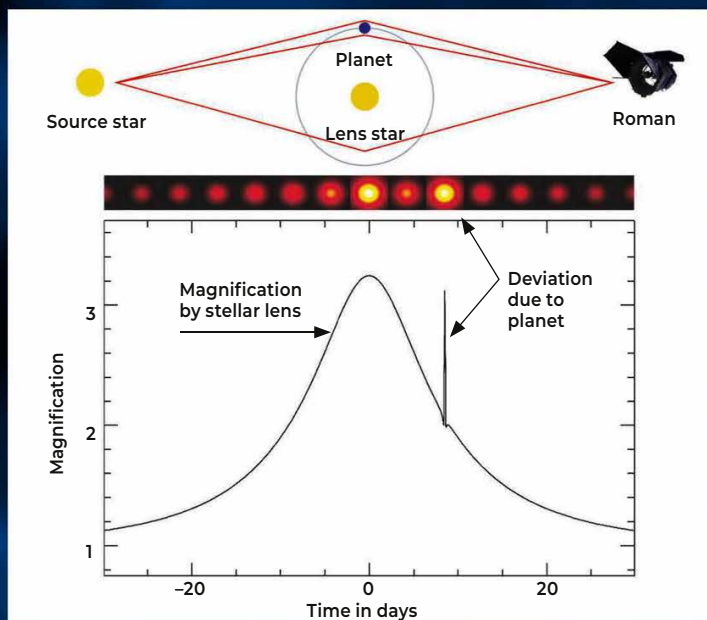
Roman's exoplanet quest

By spotting rare star alignments, Roman could discover thousands of hidden planets

Finding alien planets using microlensing is a game of chance. When a star in the foreground of an observatory happens to move in front of a more distant star, light from the distant star is magnified and distorted by the foreground star. If this nearer star hosts a planet, the planet's own gravity acts as a secondary lens, causing a tiny additional spike in the distant star's observed brightness. Astronomers can then use these spikes in brightness to calculate the mass of the planet and the distance from its parent star.

Roman's wide view and the dedicated large-scale survey of huge numbers of stars in the Galactic Bulge will be crucial to the success of this technique, because any one specific alignment of stars and planets is highly unlikely to repeat.

The observatory can peer thousands of lightyears away into the centre of the star-dense Milky Way, and so is much more likely to capture alignments as they happen. This should tell us more about how common alien worlds are throughout the Galaxy and identify targets for future study. Roman may even detect obscure free-floating 'rogue' planets that have no parent star at all.



▲ A rare microlensing event, where the smaller secondary 'blip' reveals the presence of a planet orbiting the foreground star



Building on Roman's heritage, it will be the first mission designed specifically to image Earth 'twins' – small, rocky, exoplanets orbiting in their star's habitable zone – to study their atmospheres for signatures of alien life.

Roman's unique combination of image quality and survey speed is its superpower. But it won't work alone – it is designed to complement other telescopes like Hubble and JWST. Data from Roman will also be combined and compared with results from the Vera C Rubin Observatory in Chile and ESA's Euclid mission. There's always a trade-off between any telescope's field of view and its resolution, but using different, specialised telescopes together can circumvent this.



Caroline Harper is the head of space science at the UK Space Agency and the author of *Unseen Universe*

At one end of the scale there's Rubin, with its giant mirror and camera, sweeping the entire Southern Hemisphere sky from its Chilean mountaintop every four nights, and identifying vast numbers of objects and events, many of which merit more detailed scrutiny. Roman's field is much narrower, but it is still very wide for a space telescope. Its resolution is much greater than Rubin's, and because it doesn't have to contend with interference from Earth's atmosphere, it can perform follow-up observations on objects that appear blurred to Rubin.

A telescope team effort

At the other end of the scale is the JWST, the ultimate zoom lens. Its field of view is significantly less than Roman's – it would take centuries to scan the sky with it – but it can focus with pinpoint precision and exquisite detail, looking back at even the faintest, most distant objects, almost to the dawn of time. With all these missions working together, the potential to advance our knowledge is almost unfathomable.

So is Roman the most efficient space telescope ever? The final word on that goes to Dr Nicky Fox, who leads NASA's Science Mission Directorate: "Roman will be the most stable telescope and the best coronagraph ever flown," says Fox. "This mission is the culmination of 20 years of design and work – and NASA is nine months ahead of schedule and under budget. Space is not for the faint of heart, and the Roman team exemplifies taking big risks for even bigger successes." 🚀

Chasing the CORONA

When **Yvette Cook** travelled to rural Spain in search of a perfect eclipse, she discovered that totality is as much about the people beside you as the sky above



Light has returned. Sitting on the grassy bank of a limestone hilltop, I watch a golden glow spread across harvested wheat fields below and hundreds of beaming faces around me. It's 12 August and everyone is trying to make sense of the total eclipse they've just experienced – gazes of awe, cries of 'qué bonito' and a cool electricity in the air, like the moment after a lightning strike.

For a few extraordinary moments, the Sun's disc was covered and something usually invisible became visible: the delicate streamers of its corona. They looked almost weightless, not part of a star capable of releasing unimaginable amounts of

▲ Yvette and friends headed to Medinaceli for 100 seconds of darkness, and left with memories to last a lifetime

energy. My friend Cristina is still staring upwards. "It was like a portal onto physics," she says. "The perfect astronomical phenomenon."

Everyone has been looking forward to the moment of totality, but nobody seemed prepared for what came afterwards. Tears are flowing, goosebumps are rising and people are struggling to describe the moment. "You have to experience it to understand it," Cristina's daughter, Tania, says. "It's just one of those things you can't put into words." Totality is over, but the feeling lingers, as though it has taken us somewhere beyond the ordinary.

I'm an umbraphile, a solar-eclipse chaser, and what draws me is how no two eclipses are the ►

Spain's total solar eclipse on
12 August unveiled the delicate
corona that eclipse-chasers
travel the world to see





► same, whether it's the exact colour of the darkness, the audience's reaction or, if you're lucky, the crystal-clear view of the Sun's corona.

After partial cloud obscured most of my last eclipse in North America, this time I was eager to see the corona. Iceland offered two minutes and 18 seconds of totality, but I chose to instead head to Spain, sacrificing 37 seconds for better odds of clear skies. My research led me to Medinaceli, a rocky hilltop village on the high plateau of Castile and León, located in a designated Starlight Reserve and with a western horizon unobstructed by mountains.

A time to be together

There was another reason this eclipse mattered: I could share it with my daughter Charlotte and our Spanish friends from Girona, Cristina, Tania, Jan and Zara. Charlotte had seen an eclipse in Oregon, but then aged six she was too young to understand what she was watching.

Together we drove two hours northeast from Madrid, arriving two days before the eclipse. The drab motorway gave way to rocky limestone hills, their summits crowned by ruins of fortified castles and rows of wind turbines. Sunflower fields brightened the summer-scorched landscape and eagles soared overhead. Medinaceli's Roman arch, medieval castle and Renaissance church appeared, testament to its long history and strategic importance. Now it was preparing for a different kind of invasion.

It was a good job we'd planned ahead, as accommodation in Medinaceli was fully booked almost a year in advance. As Charlotte and I checked into our guesthouse, we met retirees Rob and his partner Christine from the US. "I experienced the eclipse in Oregon," Rob told me, "and I want to share that magical moment with Christine this time." Charlotte started sharing her eclipse story and, before we'd even finished introductions, we were already swapping eclipse tales and hopes.

Exactly 48 hours before totality, we ventured to the town's west-facing Puerta Arabe, a medieval Arab gateway in its fortified walls. With totality due to take place 45 minutes before sunset, I needed to be sure that the viewpoint I'd chosen was going to be high enough to see the whole event. House martins swooped overhead, the valley glowed gold and off to my left the castle's flags flapped in the breeze. Most importantly, I had a clear view of the Sun. With a favourable weather forecast, all we could do now was wait.

▲ Yvette picked the historic hilltop village of Medinaceli as a prime spot to witness totality



Yvette and daughter Charlotte prepared to experience their first total eclipse together



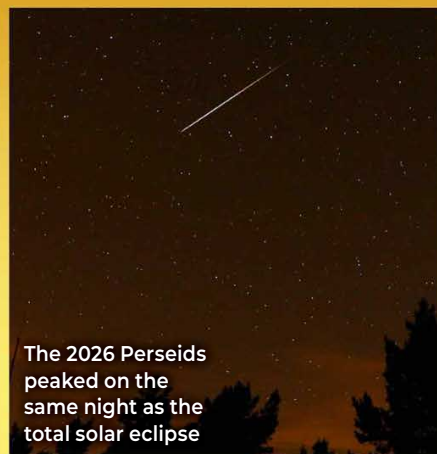
Yvette checked that they'd have a clear view from Medinaceli's hillside

A stargazing two-for-one

Astronomers had a double treat when the Perseid meteor shower peak followed the eclipse

The eclipse wasn't the only celestial event competing for attention in Spain on 12 August 2026. That night, the annual Perseid meteor shower was at its peak, when a waning crescent Moon meant skies were dark.

In Medinaceli, the Perseids formed part of Fundación DEARTE's eclipse programme. Over two nights of Perseid spotting, their experts led families into the shadows of Medinaceli's castle as the shower approached its peak – a good dark-skies location as Soria, the province in which Medinaceli sits, is a Starlight Reserve. With many using phone lights



The 2026 Perseids peaked on the same night as the total solar eclipse

to navigate the rough ground, it was a good reminder that a red torch is a better companion for a night's stargazing.

And the celestial show continues later in the year. The Orionid meteor shower peaks around 21–22 October, with the best viewing towards Orion in the southeast after midnight, when there will be less moonlight interference. With the right conditions, you may be able to see up to 20 meteors per hour. Then, around 14 December, the Geminids peak during a new Moon, with up to 150 meteors per hour, including what could be some of the year's brightest.



▲ Fundación DEARTE marked the eclipse with a full programme of events

based in Medinaceli's historic Ducal Palace, had made the eclipse a three-day celebration. Its programme, Eclipse en la Ciudad del Cielo (Eclipse in the City of the Sky) brought astronomy and culture together through talks, pinhole-camera workshops, meteor spotting, a concert and a time capsule.

"We've tried to organise something to give people greater understanding and enjoyment of the eclipse," the event coordinator Óscar Tugores told the audience as he opened the event. The eclipse also inspired an exhibition mixing astrophotography and artistic responses to the cosmos, including Hubble's Pillars of Creation.

The big day arrives

Eclipse Day in rural Spain was much calmer than I had experienced before. Medinaceli's cobbled



▲ Ahead of totality, Daniel Torregrosa (left) and Luisa Achaerandio (right) reflected on eclipses in science and storytelling, and their power as a shared emotional experience

On the eve of Eclipse Day, Medinaceli was already changing as tents sprang up and photographers unpacked equipment.

Fundación DEARTE, the not-for-profit cultural organisation

lanes were quiet, as locals relaxed in bars or sought shade from the brutal 36°C (97°F) heat. Inside the Ducal Palace, science communicator Daniel Torregrosa captivated the audience with stories of mythology, superheroes, science fiction and even *The Simpsons*. He explored how humans have always used stories to make sense of the unknown and how eclipses continue to shape our culture.

But it was educator and outreach speaker Luisa Achaerandio who captured the emotional power of the eclipse. Using the famous Voyager 'Pale Blue Dot' image of Earth, she reminded us of both our insignificance in the cosmos and our extraordinary capacity to understand it. She spoke of how sudden darkness, which once inspired fear and uncertainty, today gives us a reason to pause and look up together.

"The light always returns," she said. "But when the shadow arrives, it seems we are abandoned."

With 90 minutes to go until the eclipse, colourful umbrellas dotted the hillside. Families spread blankets and cool boxes across the grass, some guarding their patch while others sought shade. ►



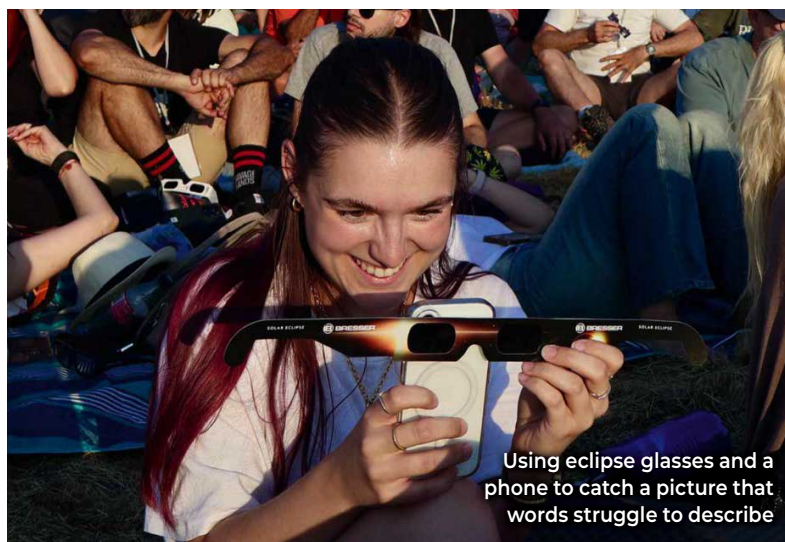
Telescopes and cameras at the ready as eclipse-watchers claim their spots



Safety first: fitting a solar filter before the moment of first contact



Crowds gather on the hillside in the 36° Spanish heat. The countdown is on



Using eclipse glasses and a phone to catch a picture that words struggle to describe

► Eclipse glasses appeared, while camerapeople assembled their equipment and amateur astronomers fitted solar filters to their telescopes.

Then, 15 minutes before first contact, hundreds of people poured out of the village. Our little patch of grass suddenly felt precious when two women positioned themselves directly in front of us on stools, blocking our view and refusing to move. The usual sense of eclipse camaraderie evaporated somewhat as my sightline disappeared.

But my mood soon shifted as I spotted first contact, and people settled into their positions, growing noticeably quiet. "It's nice to see everyone together to experience something that doesn't happen very often," my friend Zara said.

Totality – and tears of joy

This felt different from eclipses I'd experienced elsewhere. The setup was simpler and more intimate, sharing the moment rather than focusing on experiments to project the shrinking Sun. Phones were held behind eclipse glasses as people tried to capture the moment. "I've got it!" Cristina's son Jan shouted, proudly passing his phone around.

Soon, the light began to change. "It's like a sunset while the Sun is in mid-air," Tania said. Beside us, Pilar, a local who experienced Spain's 2005 annular eclipse, noted that it was feeling more windy and cool as the air temperature dropped. "We need some respite from the heat," Tania added.

The partial phase seemed to accelerate. Charlotte's excitement was building. "I feel like I'm going to experience it properly, as I actually know what's going on now," she said. I didn't need to look at my watch to know the time had come.

The Moon squeezed out the last sliver of sunlight and Baily's beads flashed. Then came the final burst of the dazzling diamond ring effect.

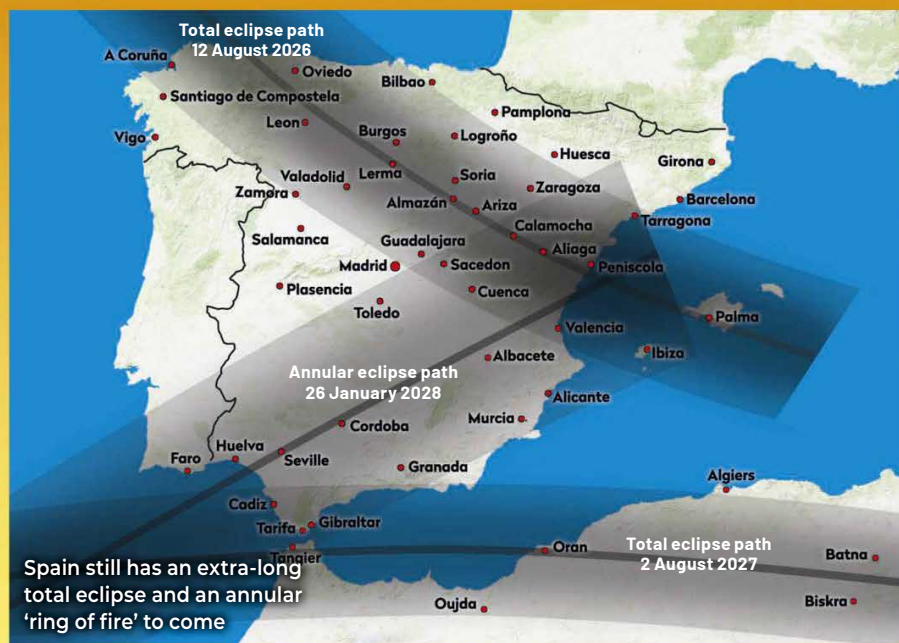
Darkness. The black disc of the Moon hung above us, surrounded by wisps of white light unfurling from the Sun, ghostly as cobwebs caught in a breeze. That corona I'd travelled all this way to see was suddenly there and I was entranced.

Screams of joy brought me to my senses and I naturally joined in. In the dusky light, Venus was revealed shining high in the sky and lights blinked on distant wind turbines. My friends were either beaming or agog, wonder imprinted on their faces.

I scanned the horizon from one side to the other: sunset, nighttime and sunrise seemingly compressed into a single view. Copper and rose light glowed on either side, while above us the sky had become a deep blue-black. It wasn't just a view. I could feel the eclipse changing the temperature of my skin, and the hairs on my arms rose.

Spain's rare run of solar eclipses

Between 2026 and 2028, Spain experiences three solar eclipses very close together



path of totality will pass through Cádiz and the Strait of Gibraltar. It's being heralded as a once-in-a-lifetime event as it will be the longest total eclipse of the 21st century, with four minutes and 40 seconds in Tarifa and a maximum of six minutes and 23 seconds in Luxor, Egypt.

On **26 January 2028**, Spain will experience an annular solar eclipse, creating the famous 'ring of fire' effect as the Moon passes in front of the Sun without completely covering it. Transiting along a line from Seville to Valencia, the annular eclipse will last around seven minutes, depending on your viewing location.

This trio of eclipses so close together is exceptionally unusual, not least as the next total eclipse visible from mainland Spain after 2028 won't be until 2053.

For eclipse enthusiasts, that makes the coming years a rare window to combine spectacular celestial events with a journey through Spain's cities, coastlines and landscapes, and an opportunity to seek out new dark-sky destinations.

Spain has entered an unusually busy period for eclipses, with three major solar eclipses crossing the country within 18 months.

The sequence began with the total solar eclipse of 12 August 2026 across northern Spain. Next will be southern Spain's turn on **2 August 2027**, when the



After a few photographs, I sank back into Charlotte's arms. She hugged me tightly, her cheek against mine, tears running down her face. "It's so beautiful, Mum," she repeated.

In that embrace, I remembered Luisa Achaerandio's words from earlier in the day: "in that instant, we only have each other, waiting together, for the light to return."

And then it did.

The first flash of returning sunlight broke across the Moon's edge and the crowd erupted into



Yvette Cook is an award-winning travel journalist, eclipse chaser and stargazer

applause. Daylight flooded back over the plateau, but the eclipse hadn't finished yet.

Now the partially eclipsed Sun was sinking towards the horizon. Around us, people compared photographs and excitedly exchanged impressions of what they had seen. For a few hours, our viewpoint had become a gigantic natural observatory, a privileged window into the sky.

The landscape took on a dusty red colour as the tip of the Sun's crescent descended below the hills. Charlotte squeezed my hand. As the Sun set over the Castilian plateau, the light was leaving us again, and none of us felt ready to leave with it. 🌑

The death of a massive star creates one of nature's greatest spectacles. We explore why we're still waiting for the show

Where are all the Milky Way's supernovae?

Supernovae should erupt in our Galaxy every few decades. So why haven't we seen one for more than 400 years, asks **Giles Sparrow**?

When a monster star dies at the end of its short, brilliant life, or a heavy white dwarf suddenly destroys itself, the results are spectacular. Both events create supernovae, eruptions that for weeks or months can outshine an entire galaxy. They're not only an unforgettable sight, but also offer a vast treasury of scientific data, packed with clues to how stars live and die.

Past supernovae in our own Milky Way became some of the brightest stars in the night sky, recorded in chronicles around the world. Yet astronomers face a frustrating reality: not one supernova has been seen in the Milky Way since the invention of the telescope more than 400 years ago.

Historical records suggest that before the early 17th century, these celestial interlopers appeared at roughly one per century, but this pattern ends with Kepler's supernova of 1604, a brilliant beacon in Ophiuchus. For the century or so that supernovae have been

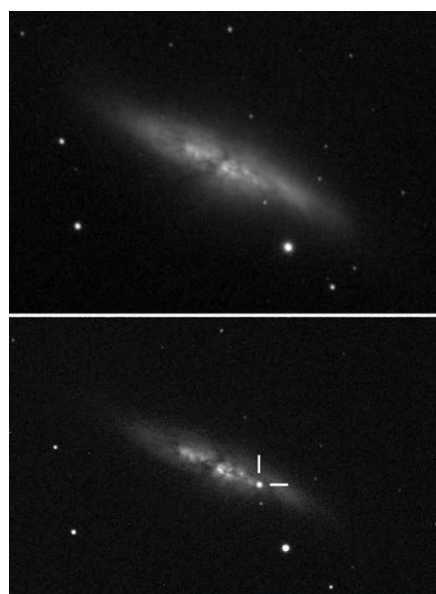
understood as a distinct phenomenon, they've only been observed in distant galaxies, often millions of lightyears away. These remote events have transformed

astrophysics, helping measure cosmic distances and reveal how heavy elements are scattered through space. Even so, the chance to study one in our cosmic backyard seems overdue. But is that really true?

Is ours overdue?

One step towards answering this question is to confirm how often supernovae should occur in spiral galaxies like ours. In 2006, a team led by Roland Diehl of Germany's Max Planck Institute used the European Space Agency's orbiting INTEGRAL observatory to measure gamma rays from aluminium-26, a radioactive isotope forged in massive stars and their supernovae, then spread by stellar explosions.

They found that the Milky Way holds about three solar masses' worth of these rare atoms. Because Al-26 decays on million-year timescales, this reservoir must be continuously replenished – a process requiring, on average, one 'core-collapse' supernova (the death of a massive star) roughly every 50 years.



▲ SN 2014J blazed in the Cigar Galaxy (M82) in 2014 – the closest supernova in decades, at 11.4 million lightyears away



Seen in AD 1054, the Crab Nebula remains the Milky Way's only confirmed historic core-collapse supernova

“Part of the answer is that, despite their brilliance, supernovae can be surprisingly elusive”

This boosts the expected frequency considerably, but also raises another point: most remnants linked to historic explosions seem to come from the other type of supernova – Type Ia, marking the destruction of white dwarf stars. So far, the only confirmed core-collapse supernova on record is the AD 1054 explosion that created Taurus's famous Crab Nebula. So where are the others?

Part of the answer is that, despite their brilliance, supernovae can be surprisingly elusive. One of the brightest radio sources in the sky, Cassiopeia A, marks the afterglow of a supernova that simply wasn't recognised at the time. Rewinding the expansion of its hot gas clouds shows they came from a core-

collapse supernova whose light would have reached Earth around 1667, when it should have rivalled the brightest stars. An even younger Type Ia remnant in Sagittarius, G1.9+0.3, should have been visible in the period around 1890–1910.

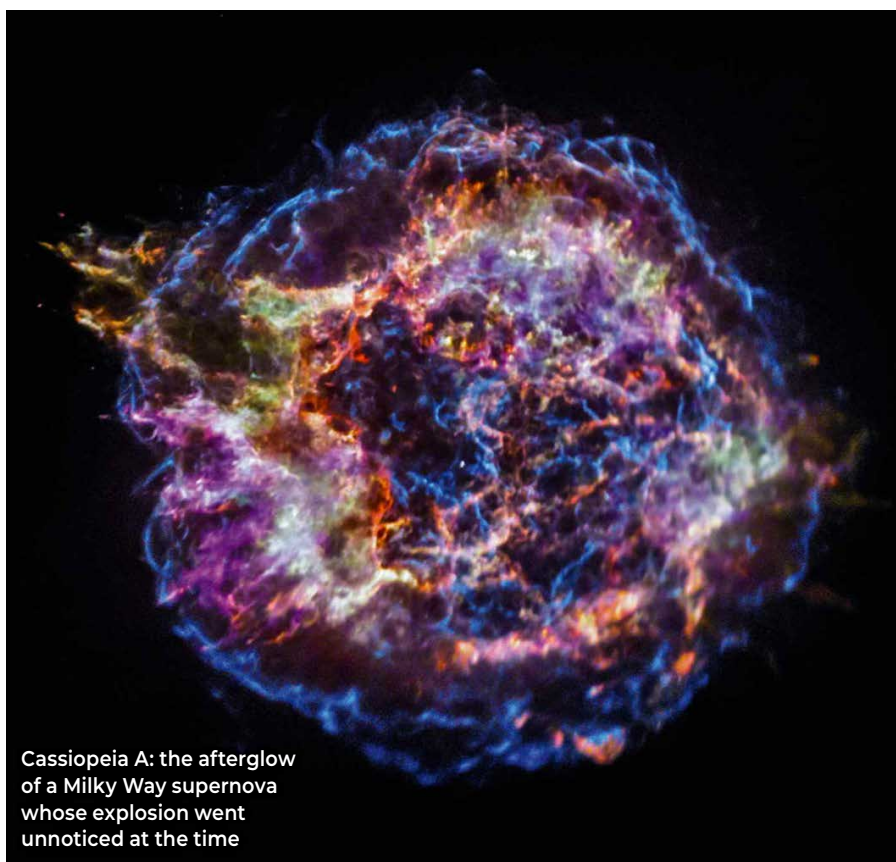
Hidden in plain sight

Some researchers suggest Cassiopeia A may have been recorded in contemporary catalogues as a faint, unremarkable star, but the Sagittarius event certainly went unseen. Both lay behind dense clouds of dust and stars in the Milky Way's flat central plane. Their wreckage has only been revealed since the mid-20th century by radio, infrared and X-ray telescopes picking up radiation that passes straight

through these clouds. Could other hidden events still be awaiting discovery?

Modelling in 2021 suggests we should expect most supernovae to be hidden from Earth. A University of Illinois team showed that core-collapse supernovae concentrate in a narrow region of the galactic plane called the 'thin disc'. This gas- and dust-rich environment is where nearly all stars form in the Milky Way and, because massive stars destined to explode as supernovae live fast and die young, they don't last long enough for their orbits to be tilted or 'scattered' into the surrounding 'thick disc', where they would be easier to see. The team estimated that only 13 per cent of core-collapse supernovae would be bright enough to see from Earth. By contrast, about one third of Type Ia events should be obvious, because they involve older stars in more scattered orbits.

It seems, then, that our Galaxy probably produces more supernovae than we expected, but chance decides which ones reveal themselves. For now, it's a waiting game, made more tantalising because the next blast could first announce itself as a ripple of neutrinos rather than a visible new star. Thanks to sophisticated particle detectors, scientists should receive an instant alert the next time a supernova erupts in the Milky Way, while orbiting telescopes monitor it in real time. Us amateur stargazers and professional astronomers on Earth, meanwhile, must hope that when it comes, this stellar explosion is well placed to deliver a spectacular celestial show. 🌌



Cassiopeia A: the afterglow of a Milky Way supernova whose explosion went unnoticed at the time



Giles Sparrow is a science writer and a fellow of the Royal Astronomical Society



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Travel with Confidence





The Sky Guide

NOVEMBER 2026

MORNING SPECTACLE

Things are afoot in the morning sky this month, with a beautiful dance between Mars, Jupiter, Regulus and the Moon

AURIGA'S JEWELS

Six captivating clusters to seek out with your telescope

MOON MEET-UP

Catch the show as Jupiter's Galilean moons get sociable

About the writers



Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four



Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- ♦ Lunar occultation of M44
- ♦ Leonid meteor shower reaches its peak
- ♦ Uranus at opposition
- ♦ Colourful targets in Cygnus and Cepheus

Red light friendly



To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

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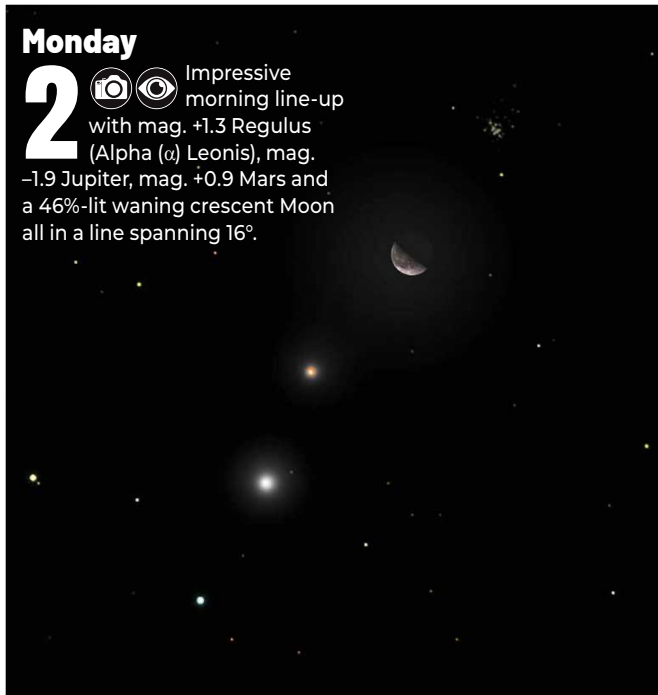
NOVEMBER HIGHLIGHTS

Your guide to the night sky this month

Monday

2

  Impressive morning line-up with mag. +1.3 Regulus (Alpha (α) Leonis), mag. -1.9 Jupiter, mag. +0.9 Mars and a 46%-lit waning crescent Moon all in a line spanning 16°.



Tuesday

3

  This morning, the 36%-lit waning Moon sits 2.2° southeast of Jupiter.



 At 09:00 UT under daylight conditions, Regulus is 1.5° north of the 33%-lit waning crescent Moon.



Saturday

7

  At 06:30 under brightening dawn twilight, mag. -4.3 Venus isn't alone. Sitting 2° to its right (as seen from the UK) is a slender 4%-lit waning crescent Moon, while 1.3° to its left is mag. +1.0 Spica (Alpha (α) Virginis).

Sunday

8

  This month's Deep-Sky Tour on page 57 takes a look at some iconic objects within Auriga, including the famous Messier trio of open clusters, M36, M37 and M38.

Saturday

14

 This month's Star of the Month (see page 53), Alnilam (Epsilon (ε) Orionis), is currently due south at 02:00 UT.

Sunday

15

  It may still technically be autumn, but winter's Orion constellation reaches its peak altitude due south at 02:00 UT – a glorious sight, with Mars and Jupiter together to its east, and Saturn approaching setting to its west.



Monday

23

  Asteroid 344 Desiderata reaches opposition, shining at mag. +12.6 as it tracks north of the Pleiades and Hyades.



 Libration is currently favourable for a view of the Mare Orientale region.

Tuesday

24

  Today's full Moon occurs approximately a day ahead of lunar perigee, making this a perigee full Moon or supermoon, one that's slightly larger and brighter than an average full Moon.

Family stargazing



It will involve a few early mornings, but seeing the dance between Jupiter and Mars this month is worth it. Jupiter is the slower mover and together with the bright star Regulus (Alpha (α) Leonis) makes a good reference against which to track the rapid motion of Mars. Get your young astronomers to sketch the arrangement, recording at least Mars, Jupiter and Regulus, but other stars too if they like. Add the date and time to each sketch. With a few results collected over several mornings, compare them to see just how fast Mars is when you're keeping an eye on it! www.bbc.co.uk/cbeebies/shows/stargazing



Saturday

28

  From around 21:30 UT, a 74%-lit waning gibbous Moon can be seen occulting M44, the Beehive Cluster.





Wednesday ►

4   The evening terminator is moving in on this month's Moonwatch target (see page 52), the beautiful Bay of Rainbows, Sinus Iridum.



◀ Thursday

12   Peak of the Northern Taurid meteor shower (ZHR 5 meteors per hour). Despite its low rate, the absence of moonlight interference will make this year's broad peak favourable.

Friday

13   Minor planets 2 Pallas and 4 Vesta are currently close to one another in Cetus. Turn to page 53 for more information.

Monday

16   Mars sits 1.2° north of Jupiter, a dramatic pairing visible in the morning sky.

  The Lunar X and V clair-obscur effects are visible on the Moon this evening from 20:00 UT.

Tuesday

17   Tonight and into tomorrow morning, the Leonid meteor shower reaches peak activity. The first quarter Moon won't interfere as it sets as the Leonid radiant rises. Best rates are likely in the morning, when the radiant gains altitude.

Friday

20   Mag. -0.4 Mercury reaches greatest western elongation, 19.6° from the Sun, rising two hours before sunrise.

  This evening's 81%-lit waxing Moon sits 5.4° north of mag. +0.4 Saturn.

Wednesday ►

25   Uranus reaches opposition today, shining at mag. +5.6 and located just to the south of the Pleiades open cluster.

Monday

30   See an interesting arrangement at 05:40 UT as a 61%-lit waning Moon sits 2.1° southwest of mag. -2.1 Jupiter, which itself lies 3.5° northwest of mag. +1.3 Regulus, while mag. +0.5 Mars sits 2.3° northeast of Regulus.



NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'



Family friendly

Objects marked with this icon are perfect for showing to children



Naked eye

Allow 20 minutes for your eyes to become dark-adapted



Photo opp

Use a CCD, planetary camera or standard DSLR



Binoculars

10x50 recommended



Small/medium scope

Reflector/SCT under 6 inches, refractor under 4 inches



Large scope

Reflector/SCT over 6 inches, refractor over 4 inches



GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website.

Visit bit.ly/stargazing-top-tips to learn how to stargaze in 12 easy steps and bit.ly/choose-first-telescope for advice on choosing your first scope

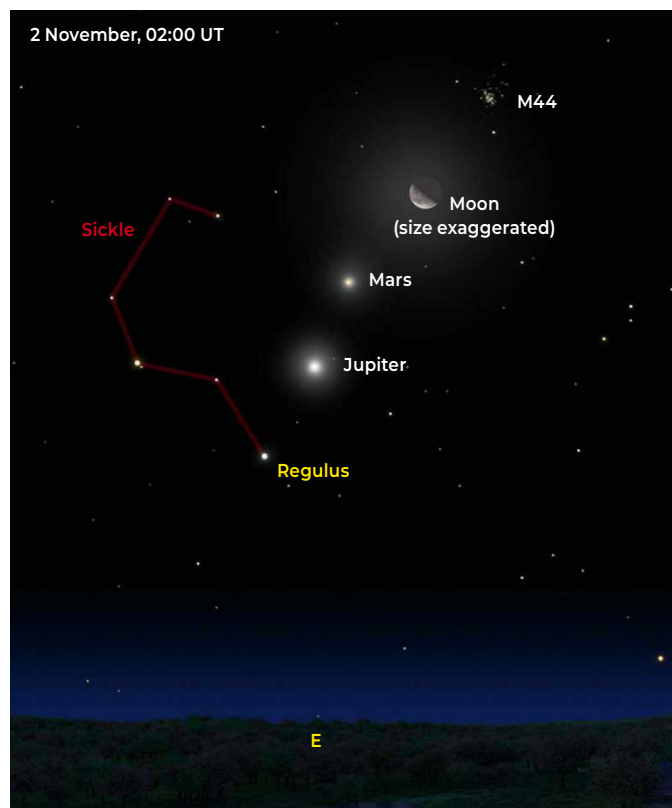
THE BIG THREE

The top sights to observe or image this month

DON'T MISS

Morning line-up

BEST TIME TO SEE: All month, especially 2, 14–17 and 28 November



▲ An impressive morning line-up can be seen on 2 November, part of an interesting period of Solar System jostling this month

There's been an impressive morning line-up building for a few weeks now, thanks mostly to Mars catching up with Jupiter. At the start of November, the pair are 5.7° apart, forming – along with Regulus (Alpha (α) Leonis) – the western half of an odd Orion's Belt-type configuration, which is to say, all three objects appear in a line, roughly equally spaced.

On 1 November, the Moon will be there too, again in line with the three aforementioned objects. With a 57%-lit gibbous phase, in the early hours the Moon will dominate the view, but Jupiter won't be far

behind, shining at mag. -1.9 . Mars will be dimmer at mag. $+0.9$, with Regulus the dimmest at mag. $+1.3$.

Also on the morning of 1 November, the Moon sits 7.5° west of M44, the Beehive Cluster, occulting the cluster later that afternoon after the pair have set (as seen from the UK). However, there's a second, better chance to see a lunar occultation of this cluster on the night of 28 November (see page 47).

Back to the morning show, and on the morning of 2 November, the waning Moon, now 46% lit, will have slid closer to Mars, the line-up of

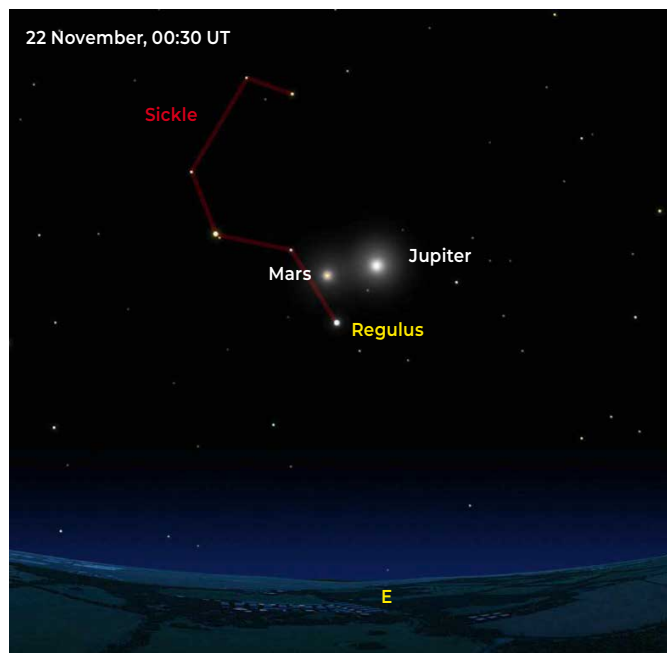
Regulus, Jupiter, Mars and the Moon forming quite an impressive straight line, again of roughly equally spaced objects. On the morning of 3 November, the Moon, now a 35%-lit crescent, will sit just south of the mid-point between Jupiter and Regulus.

As the Moon starts to move out of the group on the morning of 4 November, Mars seizes the opportunity to slide ever closer to Jupiter, passing around a degree north of the gas giant on the mornings of 14–17 November. On these dates, Mars will be a tad brighter at mag. $+0.7$. Jupiter too will have brightened, now shining to mag. -2.0 , both increases adding to the drama of the scene.

The tight isosceles triangle formed mid-month changes

shape quite rapidly over the days that follow, as Mars continues to slip east past Jupiter and closer to Regulus. On the morning of 22 November, the triangle formed by all three objects fits inside a circle less than 4° across.

On 26 November, Mars has switched sides completely, now forming the narrow base of another isosceles triangle, this time with Regulus. This fascinating pattern continues to entertain right into the beginning of December, when it can be seen rising before midnight UT. If you get clear mornings during November, try to capture a few shots of the arrangement. If you compare your photos over the days, you'll see just how much things change from one morning to the next.



▲ The pattern of Mars, Jupiter and Regulus will have tightened up considerably by 22 November, forming a snug triangle

Jupiter's mutual events

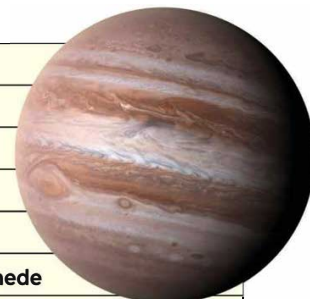
BEST TIME TO SEE: As listed

 Jupiter has a relatively small axial tilt of 3.13°. However, this still means it undergoes solstices and equinoxes. The next equinox will occur on 16 December 2026 when, in terms of its spin axis, Jupiter will be presented edge-on to the Sun. From Earth, Jupiter will also appear almost exactly edge-on.

Looking at Jupiter itself, you probably wouldn't notice anything had changed, but in the case of its four largest Galilean moons, the months around a Jovian equinox are interesting times. Io, Europa, Ganymede and Callisto have orbits very closely aligned to Jupiter's equatorial plane. When the planet appears edge-on to us, the orbits of these moons appear edge-on as well, shrinking down to extremely narrow ellipses.

Now moving back and forth either side of the planet, along trajectories that appear more like straight lines than orbits, the moons appear to interact with one another in what are known as mutual

DATE	TIME (UT)	EVENT
1 November	01:42 (5)	Io partially occults Ganymede
4 November	01:24–05:01	Ganymede shadow transit
	02:24 (5)	Ganymede partially occults Io
	06:22 (8)	Ganymede transits Jupiter
7 November	04:13 (10)	Europa partially occults Ganymede
8 November	00:07	Callisto shadow transit ends
	00:58 (9)	Callisto eclipses Europa
	04:35 (3)	Io partially occults Ganymede
11 November	05:14 (4)	Ganymede partially occults Io
	05:23 (8)	Ganymede shadow transit starts
16 November	02:42	Callisto eclipsed by Jupiter's shadow
21 November	23:08–02:48	Ganymede eclipsed by Jupiter's shadow
22 November	04:15	Ganymede occulted by Jupiter
24 November	23:11 (9)	Callisto eclipses Io
25 November	01:02–05:43	Callisto transits Jupiter
29 November	03:07–06:47	Ganymede eclipsed by Jupiter's shadow
Values in brackets = duration of the event, in minutes		



▲ Interesting Jovian moon events to look out for during November, involving Jupiter's four largest Galilean satellites: Ganymede, Callisto, Io and Europa (in size order)

events. These can take the form of one moon moving in front of another, either partially or wholly, or a moon casting its shadow on another, again either partially or wholly.

Through a large telescope, the moons appear as small discs, offering interesting opportunities to record mutual events visually or via high-res imaging setups.

For smaller scopes, two moons coming together will appear to merge for a short time, while the shadow of one moon on another will cause the eclipsed moon to fade then brighten. There's something for all sizes of scope here, so if the weather is kind, plan your observing around our events table and see how many Jovian moon interactions you can record.

Moon occults M44

BEST TIME TO SEE: 28 November from 21:40 UT

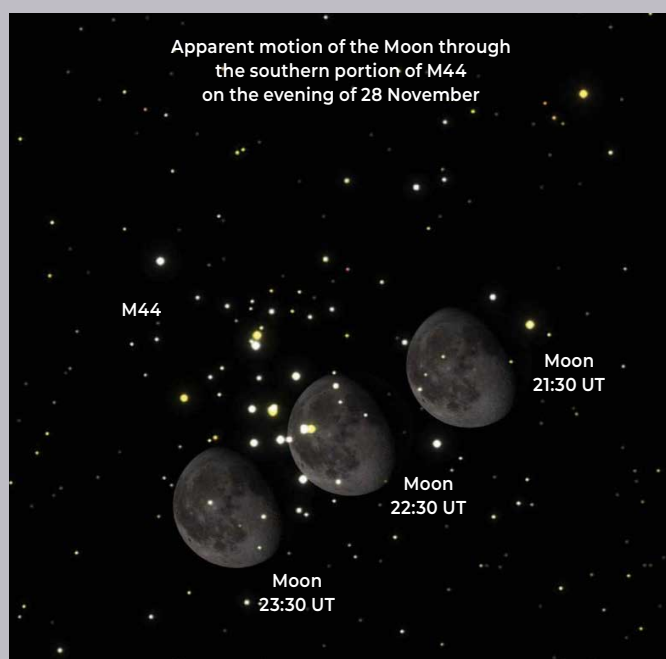
 The Moon's run of close encounters with the Beehive Cluster, M44, continues this month, when it occults several of the cluster's southern stars.

The event can be seen on the night of 28 November from around 21:40 UT. This time around, the Moon will be showing a 74%-lit waning gibbous phase. This is certainly bright enough to challenge the cluster stars, although binoculars should still reveal them near the Moon's bright limb at this time.

Once you've found the Moon around 21:40 UT, its apparent motion against the cluster is

impressive, reaching the brightest stars at the centre of the cluster just after 22:00 UT. It takes about 80 minutes to make the passage past the brighter stars.

This event will give rise to a number of occultations of stars, where cluster stars disappear behind the Moon's bright limb, reappearing some time later. A couple of the brighter members may well show grazing occultations, where the star appears to scrape along the rough edge of the Moon, hiding as it passes behind raised features and reappearing when low relief features pass in front of it.



▲ A 74%-lit waning gibbous Moon crosses the Beehive Cluster on 28 November, occulting its southern stars. The view shown is for central UK and will vary slightly for other UK locations

THE PLANETS

Our celestial neighbourhood in November

PICK OF THE MONTH

Uranus

Best time to see: 22 November, 00:15 UT

Altitude: 58°

Location: Taurus

Direction: South

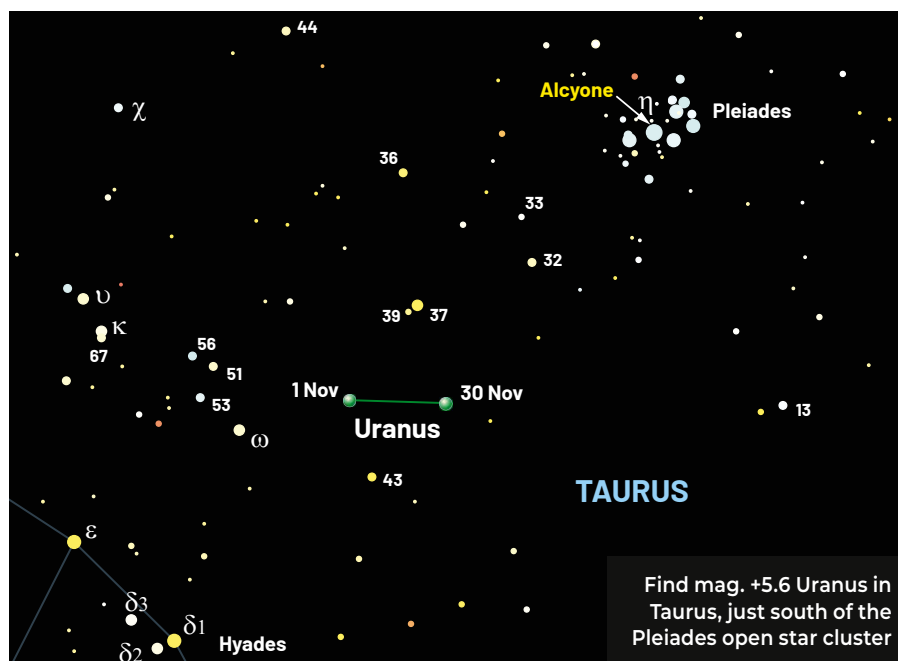
Features: Colour, subtle banding, brighter moons

Recommended equipment: 200mm or larger

Uranus reaches opposition on 25 November. At 00:03 UT that day, the planet is due south and highest in the sky, but also only 6° from a bright full Moon (it too being at opposition). For this reason, we've picked 22 November as the best time to see Uranus, as the planet will be easier to find with the Moon a little farther away.

To be honest, the appearance of Uranus won't alter much over the weeks before and after opposition, as the planet is so far away that the advantages are slight. The biggest benefit occurs because the Sun, Earth and Uranus are in a line, meaning the distance between us and the planet is minimised.

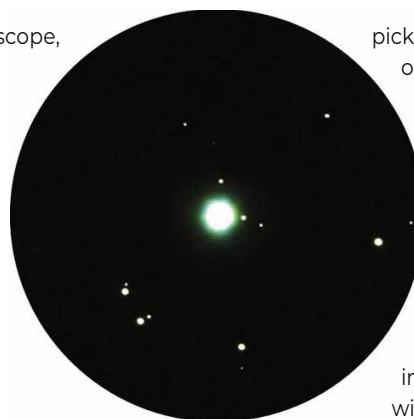
Even so, opposition brings Uranus to its brightest for the current period of observation, shining at mag. +5.6 and with an apparent diameter of 3.8 arcseconds.



TAURUS

Find mag. +5.6 Uranus in Taurus, just south of the Pleiades open star cluster

Through a small telescope, Uranus shows a tiny green-hued disc. However, large apertures are required to get anything more out of this disc and even then it can be a struggle. The most commonly observed features are subtle shading differences between different sections of the planet. A 200–250mm scope may



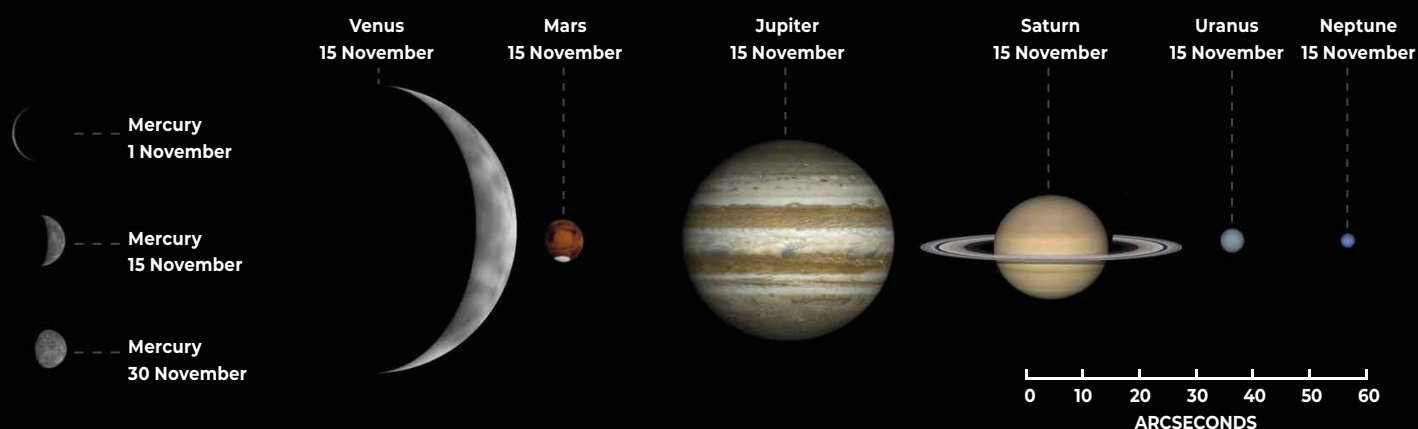
▲ Uranus captured with a Seestar S50. Titania is directly to its right, Oberon is above

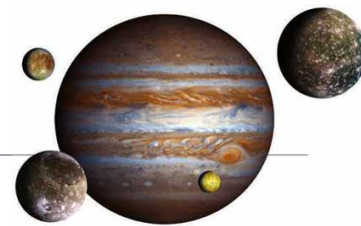
pick up the largest and outermost of Uranus's brightest moons, Titania and Oberon, but a 300mm or larger is required for moons Ariel and Umbriel, while tricky Miranda calls for at least a 400mm scope. Planetary imagers can get away with smaller apertures by using a large image scale and deliberately over-exposing the planet.

PETE LAWRENCE X 3

The planets in November

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope





Mercury

Best time to see:

20 November, 30 minutes before sunrise

Altitude: 11°

Location: Libra

Direction: Southeast

Mercury starts November as a poorly positioned evening planet. Inferior conjunction occurs on 4 November, Mercury rapidly re-emerging into the morning sky to be well placed mid-month, 13° from Venus. Shining at mag. -0.5 on 20 November, it remains bright and well placed for the rest of the month.

Venus

Best time to see:

23 November, from two hours before sunrise

Altitude: 12°

Location: Virgo

Direction: Southeast

Venus dominates the morning sky at mag. -4.1 on 1 November, brightening to -4.5 by the end of the month. It's near Spica (Alpha (α) Virginis) throughout November, arcing around the star. On 7 November, mag. -4.3 Venus is 1.3° south-southwest of mag. +1.0 Spica and 2.2° east of a 4%-lit Moon.

On 1 November, a telescope view shows a crescent, just 2% lit with an apparent diameter of 59 arcminutes. By the end of the month, Venus's phase increases to 27%, while its size shrinks to 39 arcseconds.

Mars

Best time to see:

30 November, 05:50 UT

Altitude: 50°

Location: Leo

Direction: South

Mars is an improving morning planet. At the start of November, it shines at mag. +1.3 and has an apparent size of 6.6 arcseconds. By the end of the month, it's mag. +0.5 and 7.9 arcseconds. Its tight dance

with Jupiter all month will be a calendar highlight. Turn to page 46 to find out more.

Jupiter

Best time to see:

30 November, 05:30 UT

Altitude: 50°

Location: Leo

Direction: South

Jupiter is a morning planet in Leo, close to Mars. Mag. -2.1 for much of the month, Jupiter is visited by a 34%-lit waning crescent Moon on the morning of 3 November and again by a 60%-lit waning gibbous Moon on 30 November. In the morning that day, Jupiter, Mars, Regulus and the Moon will all fit within a 7° circle.

Saturn

Best time to see:

1 November, 22:00 UT

Altitude: 38°

Location: Cetus

Direction: South

Saturn is an evening planet. Currently well placed, it's able to reach a peak altitude of 38° under dark-sky conditions all month. It begins November at mag. +0.5, but fades slightly to +0.7 over the course of the month. An 82%-lit waxing gibbous Moon sits nearby on the evening of 20 November.

Neptune

Best time to see:

1 November, 21:30 UT

Altitude: 36°

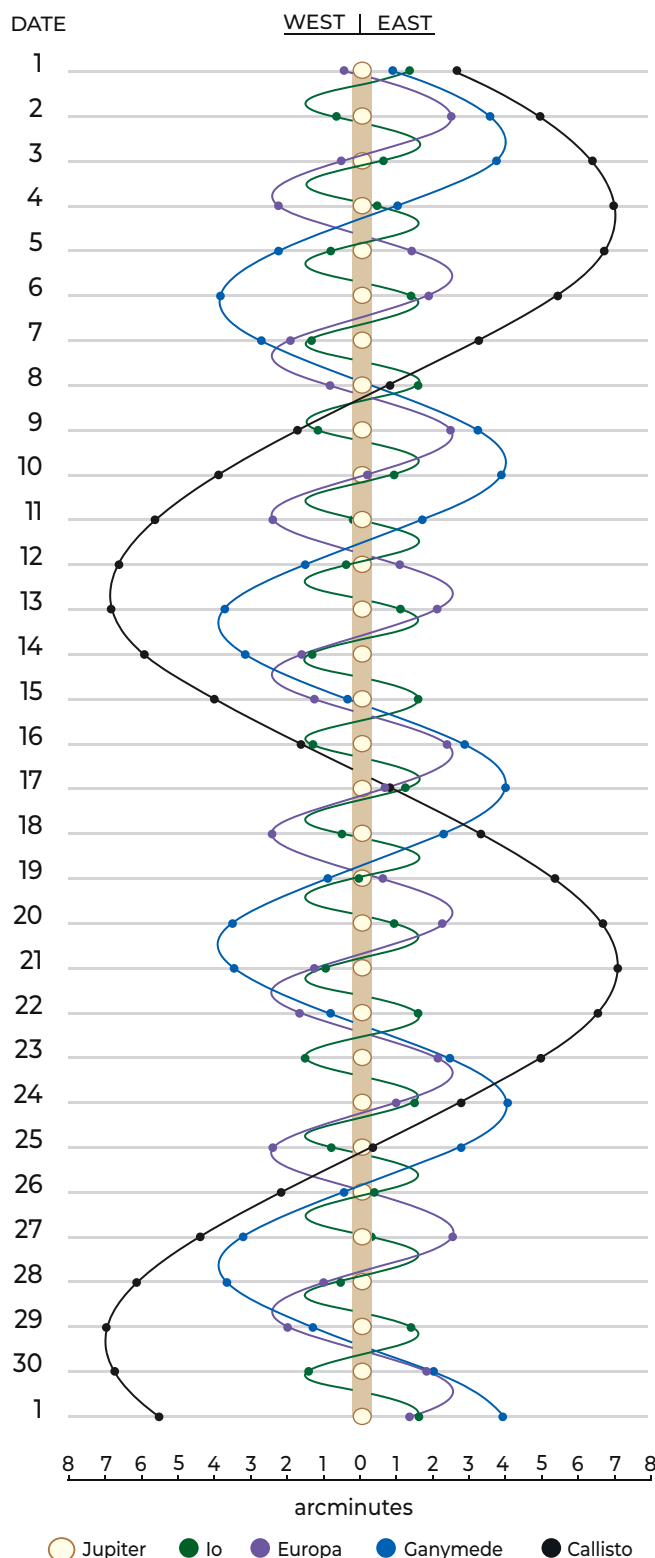
Location: Pisces

Direction: South

Visible under darkness when at peak altitude all month long, mag. +7.8 Neptune is currently located in Pisces a little over 7° to the west of Saturn at the start of November.

JUPITER'S MOONS: NOVEMBER

You can spot Jupiter's biggest moons with a small scope. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 00:00 UT.



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Print planet observing forms
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THE NIGHT SKY – NOVEMBER

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus** STAR NAME
- PERSEUS** CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE

- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH

- METEOR RADIANT
- ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

COMPASS AND FIELD OF VIEW

MILKY WAY

When to use this chart

1 November at 00:00 UT

15 November at 23:00 UT

30 November at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in November*



Date	Sunrise	Sunset
1 Nov 2026	07:08 UT	16:37 UT
11 Nov 2026	07:27 UT	16:19 UT
21 Nov 2026	07:46 UT	16:05 UT
1 Dec 2026	08:02 UT	15:55 UT

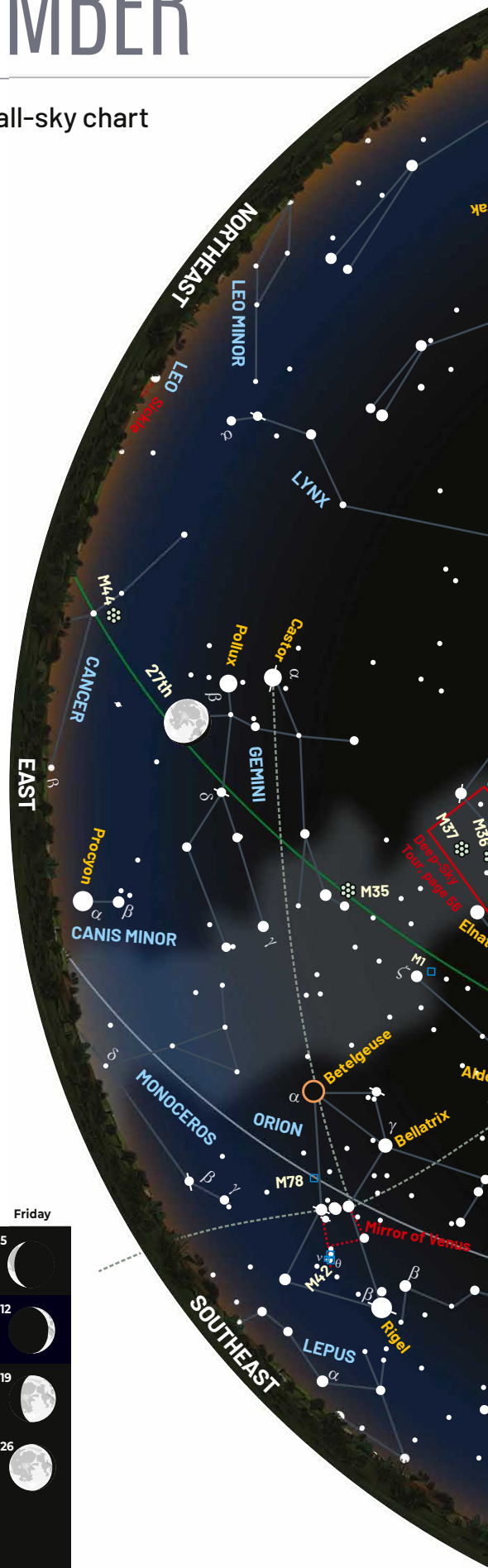
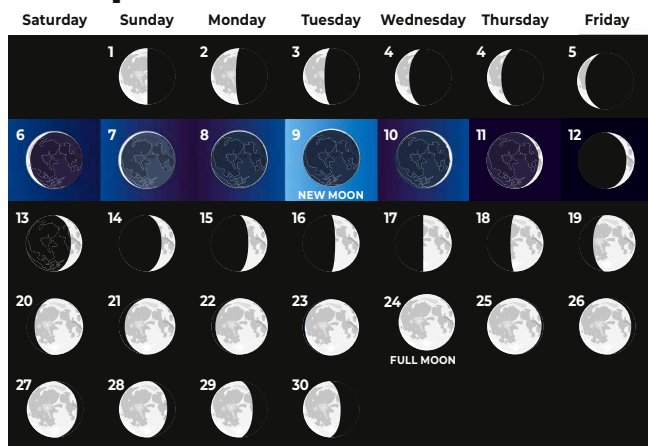
Moonrise in November*



Moonrise times	
1 Nov 2026, 22:29 UT	17 Nov 2026, 13:28 UT
5 Nov 2026, 02:43 UT	21 Nov 2026, 14:09 UT
9 Nov 2026, 08:00 UT	25 Nov 2026, 16:01 UT
13 Nov 2026, 12:08 UT	29 Nov 2026, 21:43 UT

*Times correct for the centre of the UK

Lunar phases in November



FREE BONUS CONTENT

Paul and Pete's
night-sky highlights

Southern Hemisphere guide

www.skyatnightmagazine.com/bonus-content



MOONWATCH

November's top lunar feature to observe

Sinus Iridum

Type: Lunar bay

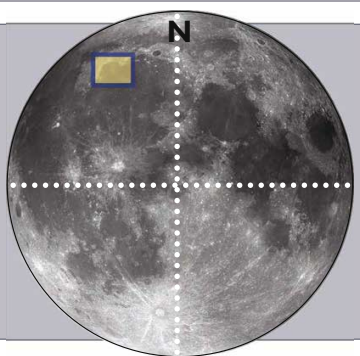
Size: 400km x 260km

Longitude/latitude: 31.7° W, 45.0° N

Age: 3.2–3.8 billion years

Best time to see: Three days after first quarter (19 and 20 November) or two days after last quarter (3 and 4 November)

Minimum equipment: 10x binoculars



Sinus Iridum, the Bay of Rainbows, is visible to the naked eye as an extension to the large dark form of 1,250km **Mare Imbrium**, the Sea of Showers. It protrudes off Mare Imbrium's northwestern boundary, forming the ear of the lunar 'basketball player'. If you're not familiar with this figure, the head is Mare Imbrium, while **Mare Procellarum** and **Mare Frigoris** form the shoulder and arm, and the ball is represented by **Mare Crisium**.

Sinus Iridum is beautifully presented, bordered by the elevated peaks of **Montes Jura**, a curved mountain range that towers above Iridum's flat floor and extends for the full length of the bay's edge. At certain times when the morning terminator approaches, the peaks of Montes Jura catch the light of the lunar dawn, forming the clair-obscure effect known as the Jewelled Handle. This beautiful arc extends into the lunar night. The southern end of the Montes Jura mountain range is marked by

"When the Sun is low, ridges in the lava appear like waves heading towards the shore"

▼ Sinus Iridum is bordered by the peaks of **Montes Jura**, which form the Jewelled Handle when the lighting is just right

Promontorium Heraclides, famous for another clair-obscure effect, Cassini's Moon Maiden. Under correct illumination, an inverted view of this region is supposed to look like the profile of a girl sitting on a rock overlooking the bay.

The northern end of the Jura range terminates at **Promontorium Laplace**, an elevated peak rising 2.7km above the surrounding lava floors of Sinus Iridum on the western side and Mare Imbrium to the east. The 11km crater **Laplace D** is located on this

headland, overlooked by the gnarled and battered form of 46km **Maupertuis** a little to the north. Another more distinct feature adjacent to the Jura range is 38km **Bianchini**, easily seen through a small scope, sitting just to the north of the mid-point along the arc. To the west of the southern portion of the arc lies

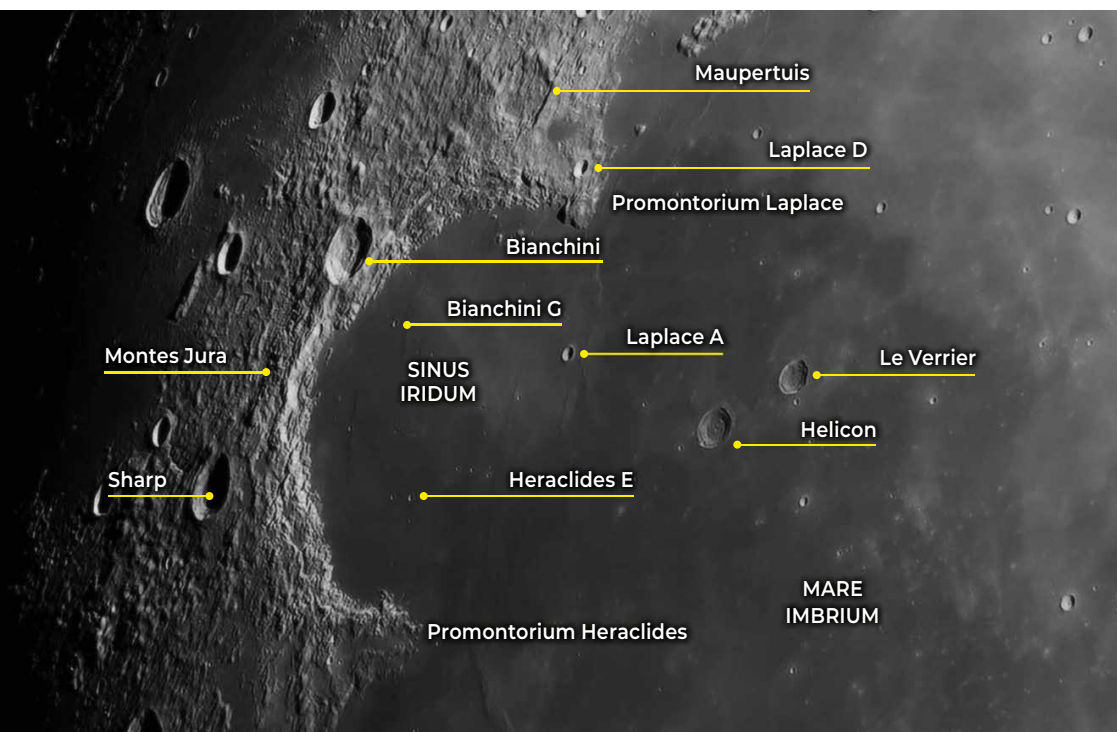
40km **Sharp**. Both Sharp and Bianchini are prominent, sharp-edged features.

Despite being described as a bay, Sinus Iridum, like all the other 'watery' lunar features, is formed with a solid lava floor. However, this floor does a great job of fulfilling its description, especially when the Sun angle is low. At such times, ridges in the bay's lava appear like waves heading towards the shore, although these waves are of course frozen in time. A large wrinkle ridge appears at the mouth of the bay, emanating from Promontorium Laplace. It passes the largest crater in the mouth of the bay, 8.2km **Laplace A**.

The sizeable area of Sinus Iridum contains only a

small number of readily observable craterlets. The most noticeable are 4km **Heraclides E** and similarly sized **Bianchini G**. A small cluster of hills appears on the bay's floor near Promontorium Heraclides, rising to a peak height just shy of 500 metres.

Leaving the bay to head southeast into Mare Imbrium, there are two distinctive craters carved into the surface of the mare. These are 25km **Helicon** and 20km **Le Verrier**. They stand out particularly well due to the lack of features around them, their appearance further enhanced by their proximity to Sinus Iridum. Their location outside of the mouth of the bay has led to them becoming known as the Guardians of Sinus Iridum.



COMETS AND ASTEROIDS

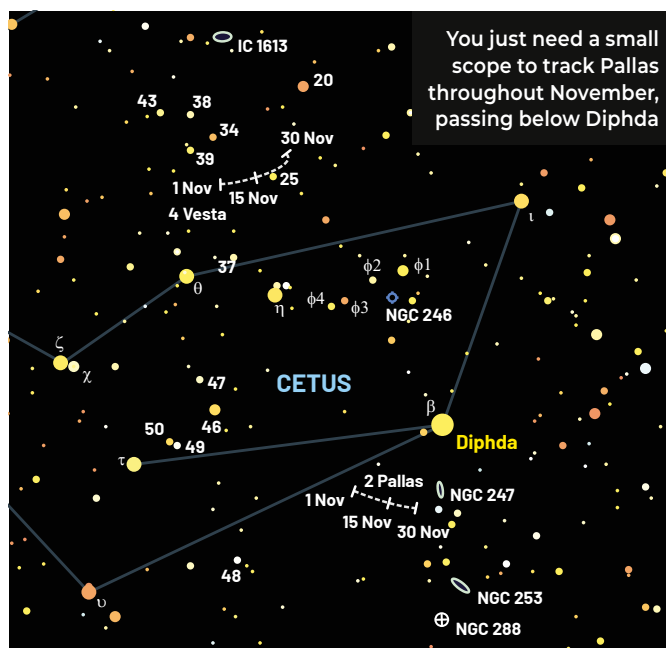
A great chance to see the second-largest object in the asteroid belt

Asteroid 2 Pallas reached opposition on 4 October and throughout November remains at a magnitude suitable for small telescopes to track. It's currently in the constellation of Cetus, not far from Diphda (Beta (β) Ceti). On 1 November, Pallas lies 4.9° east-southeast of Diphda, appearing as a mag. +8.5 star-like object through the eyepiece.

Pallas moves southwest during the month, remaining within Cetus. Its magnitude drops slightly, but only by 0.3 magnitudes, staying well within small-telescope territory. Its relatively short track over the month, coupled with the long, dark nights, offer a great opportunity to follow this famous asteroid.

Over the course of November, Pallas moves just 3.3° . During the latter half of this track, it passes to the east of the intermediate spiral galaxy NGC 247 (mag. +9.9), another target suitable for small telescopes – although with a large apparent size of 19.2×5.5 arcminutes, its surface brightness is quite low. By the month's end, Pallas lies just 1.5° from this galaxy.

Pallas is a large minor planet, second only to 4 Vesta, which is currently located 15° to the north. Pallas has a mean diameter of around 513km and, under favourable oppositions, can reach mag. +8.0. At its dimmest, it fades to around mag. +10.6, so it's fairly optimal at the moment.



Pallas was recorded by the French comet hunter Charles Messier 23 years before its official discovery by Heinrich Olbers on 28 March 1802.

Messier noted it while tracking a comet, but failed to realise Pallas was a Solar System object, assuming it was simply a background star.

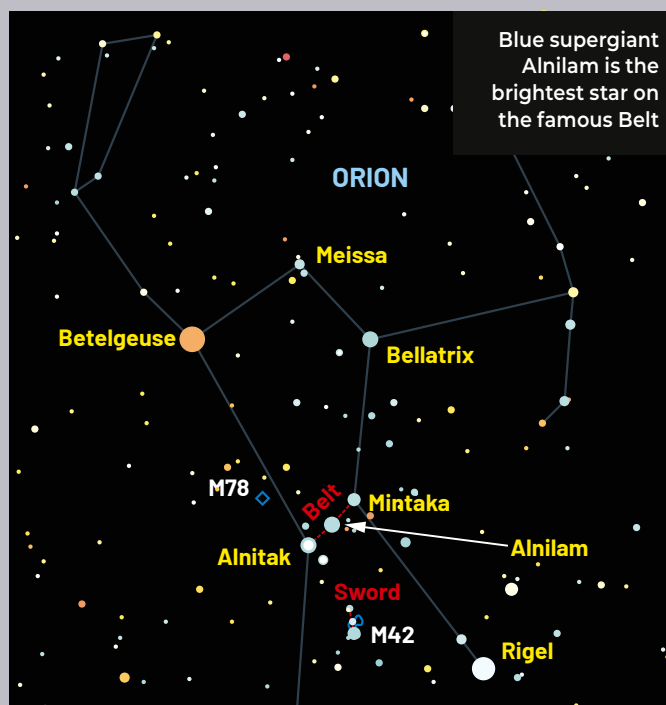
STAR OF THE MONTH

Alnilam, the blue buckle of Orion's Belt

Few stars are as easy to find as Alnilam, the brightest member of Orion's Belt. Designated Epsilon (ϵ) Orionis, Alnilam means 'string of pearls' and, like many stars in this region, is a large, powerful object.

Its spectral classification is B0 Ia, indicating it's a blue supergiant. It's 34 times larger than our Sun and 270,000 times more luminous. Alnilam is mag. +1.69, just brighter than Alnitak (Zeta (ζ) Orionis), the Belt's easternmost star (mag. +1.71), and Mintaka (Delta (δ) Orionis), the westernmost (mag. +2.3). While Mintaka and Alnilam are 1,250 lightyears from Earth, Alnitak is slightly farther at 1,260 lightyears.

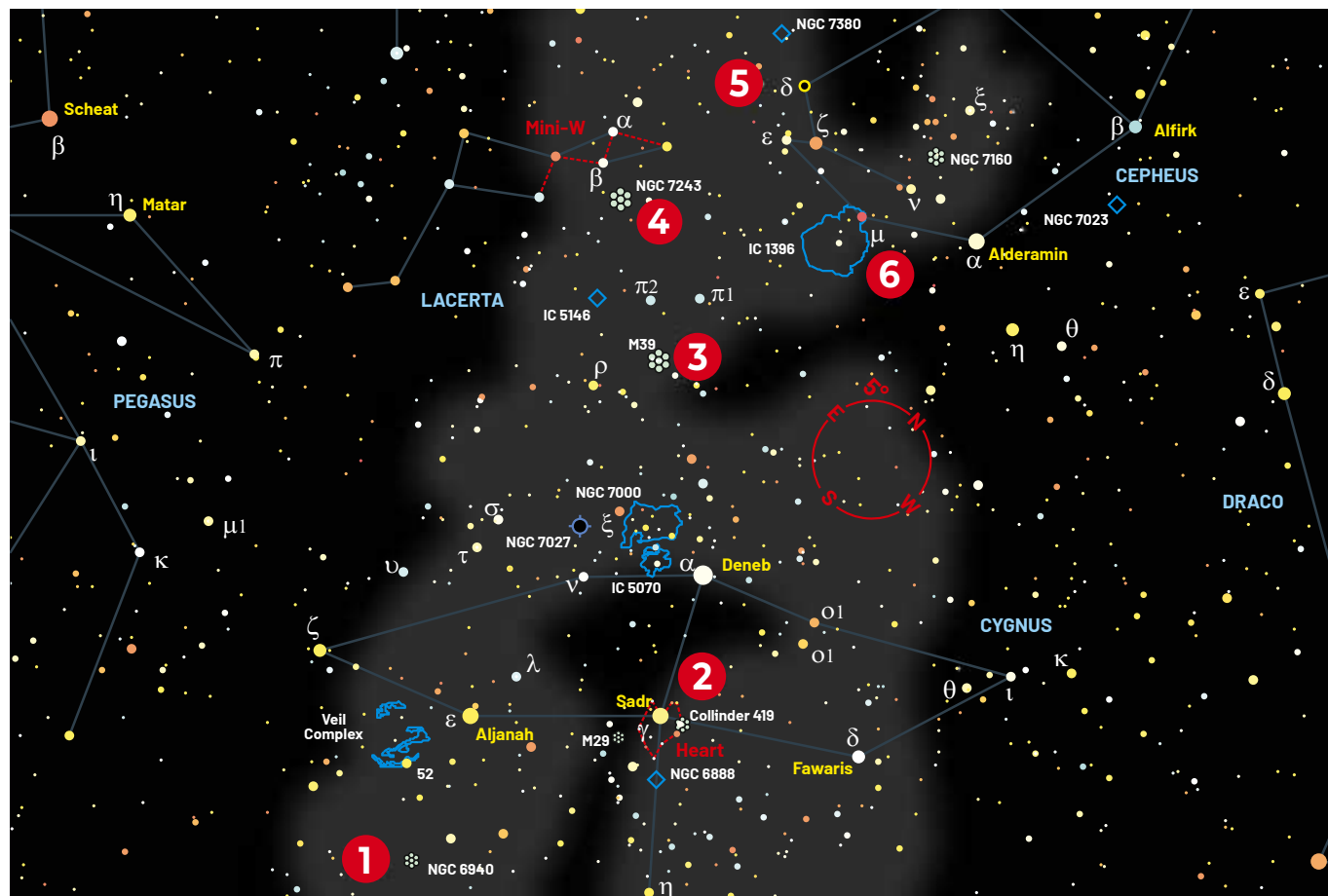
Alnilam's spectrum is used as a stable comparison for its B0 Ia class. However, it's known to vary between mag. +1.64 and +1.74, and shows no distinct periodicity. Like most stars of this class, it's losing mass to its surroundings. A powerful stellar wind removes approximately two millionths of a solar mass annually, around 20 million times greater than the equivalent loss from our own Sun. Like our Sun, it's a loner with no known companion. Alnilam is about 4 million years old. According to models, its internal hydrogen fusion is shutting down, which will eventually trigger a massive supernova.



BINOCULAR TOUR

With Steve Tonkin

Explore colourful Cygnus and Cepheus, from blue-white beauties to glorious garnets



1. NGC 6940

10x 50 To find our first target, start at mag. +2.5 Aljanah (Epsilon (ε) Cygni) and navigate just over 3° due south to mag. +4.2 52 Cygni. Then go the same distance to the southwest, where you will find an oval glow that extends to the same apparent diameter as the Moon. As you study the glow, you should be able to resolve the 2,700-year-old light of eight or so stars of this very pretty cluster.

☐ **SEEN IT**

2. The Heart of Cygnus

10x 50 Mag. +2.2 Sadr (Gamma (γ) Cygni) is sometimes called 'the heart of Cygnus', but there is a bit more to it. Look carefully and you'll notice that Sadr is also the brightest of a heart-shaped asterism of 11 mostly sixth-magnitude stars. It has a diameter of slightly less than 2° and binoculars will reveal a wide variety of colours, ranging from deep orange, through yellow and white, to an intense blue-white. ☐ **SEEN IT**

2. M39

10x 50 Given a good, dark sky and time for dark adaptation, the open cluster M39 may be just visible to the naked eye, 9° from mag. +1.3 Deneb (Alpha (α) Cygni), in the direction of mag. +4.2 Pi² (π²) Cygni. With 10x50s, you should see a wedge-shaped group of stars whose visibility is very sensitive to light pollution. Although as few as four or five may be visible in an urban sky, a rural dark sky should allow as many as 20 to be resolved. ☐ **SEEN IT**

4. NGC 7243

10x 50 On a line from Deneb, continue another 7° beyond M39 to a somewhat finer cluster of stars. Although NGC 7243 is a lovely cluster in its own right, it's also a signpost to an equally enjoyable spectacle. Relax and take in the surrounding view of this beautiful part of the Milky Way. Your binoculars will show you numerous knots and braids of stars separated by voids that are dark, winding dust lanes. ☐ **SEEN IT**

5. Delta Cephei

10x 50 Delta (δ) Cephei (mag. +3.6 to +4.5 over a period of 5.37 days) gave its name to an entire class of variable stars. Henrietta Swan Leavitt discovered the relationship between their variability period and their luminosity, allowing them to be used as a 'standard candle' for measuring galactic distances. Delta is also a beautiful double, with a deep yellow primary and a white secondary. ☐ **SEEN IT**

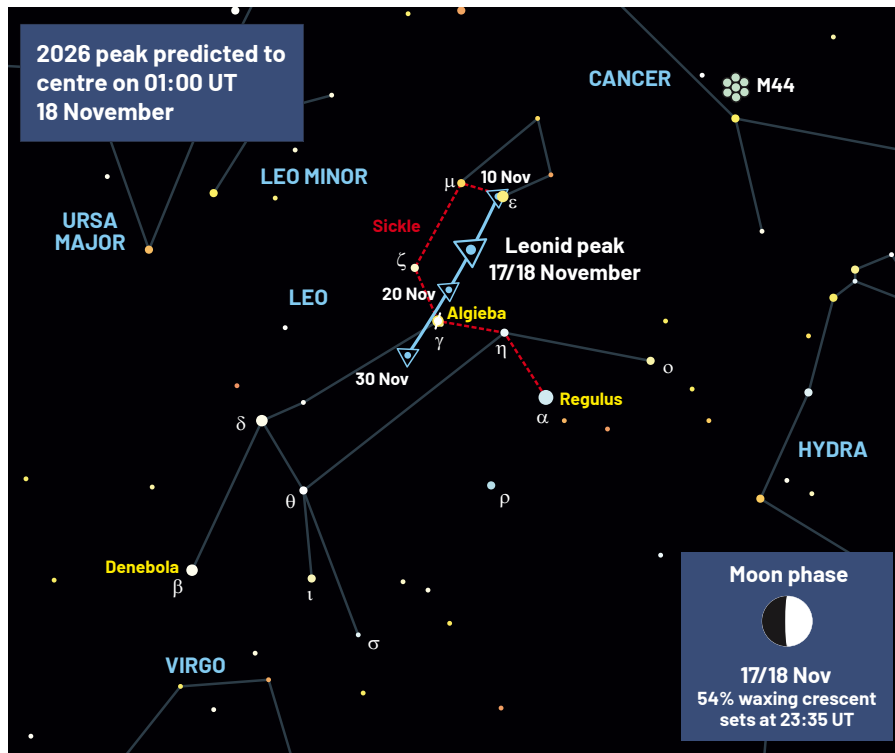
6. Herschel's Garnet Star

10x 50 Just south of the mid-point of a line between mag. +2.4 Alderamin (Alpha (α) Cephei) and mag. +3.3 Zeta (ζ) Cephei is the deep orange mag. +4.0 Mu (μ) Cephei, named for William Herschel, whose description is as apt today as it was in 1783: "a very fine deep garnet colour... a most beautiful object." You can, as Herschel did, compare its colour to Alderamin and Delta Cephei. ☐ **SEEN IT**

☒ Tick the box when you've seen each one

THE SKY GUIDE CHALLENGE

Pull an all-nighter to help record the Leonids before their next big outburst



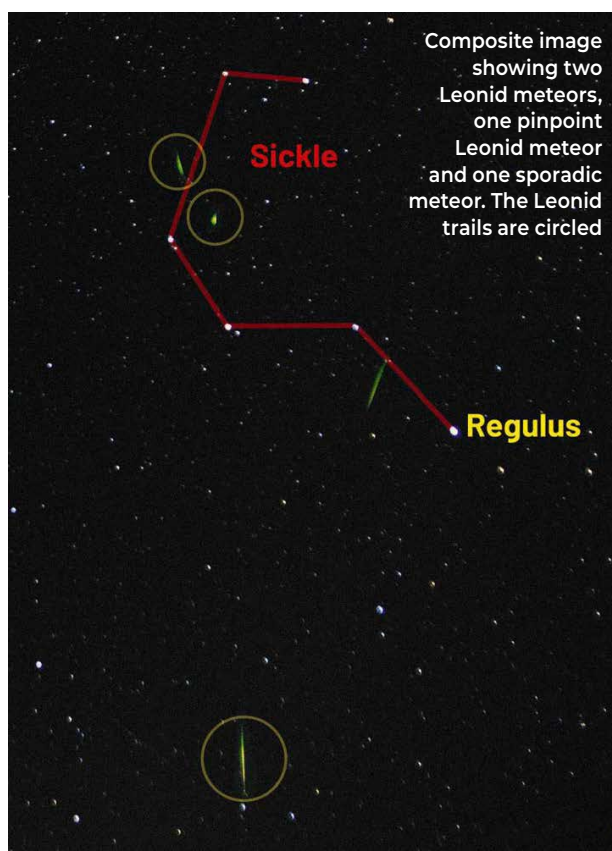
▲ The Leonid radiant lies in the head of Leo, marked by the distinctive Sickle asterism. Watch from after midnight until dawn, when meteor rates rise as the radiant climbs higher

The challenge this month is a simple one: observe the Leonid meteor shower. That may not sound too demanding, but things are a little different when you're actually out under the stars.

The Leonids are well known by name, but how well do you know their nature? They have a reputation for producing spectacular meteor storms but, in reality, these are few and far between, occurring

roughly every 33 years. Recent outbursts were seen in 1966, 1999, 2001 and 2002; if you do the maths you'll realise we're currently between peaks, with the next expected in 2033 and 2034.

These outbursts occur when Earth encounters dust trails left behind in the orbit of the shower's parent comet. Any observations made now are very valuable because they provide a control value for the shower's activity between outburst peaks. This is especially true in favourable years such as this one, as some of the years leading up to the



“Every year from now until after the 2033/2034 outburst period helps build an important record”

next outburst will suffer from interference by the Moon.

Catch the peak

The Leonids originate from the comet 55P/Tempel-Tuttle. Debris strewn around this comet's orbit produces activity from 3 November to 2 December, with this year's peak expected to centre on 01:00 UT on the morning of 18 November. The peak zenithal hourly rate (ZHR) is forecast to be around 15 meteors per hour, which is far from dramatic but, as described, important to observe.

The Moon is present around the peak, but it sets before midnight on the nights of 17/18 and 18/19 November. This is when the Leonid radiant, located in the head of Leo and conveniently marked by the Sickle asterism, is beginning to gain altitude. The closer the radiant is to the zenith, the closer the visual rate will come to the ZHR. A watch from midnight until the start of dawn will yield the best results.

If you're planning to photograph the shower, this can be a challenge in its own right. Leonid meteors are the swiftest in the sky, the meteoroids that produce them travelling at 70km/s (157,000mph). As a result, a camera needs good sensitivity because the light from a Leonid trail doesn't linger on the sensor for long.

Now is a great time to start recording the shower. Every year from now until after the 2033/2034 outburst period helps build an important record of how Leonid activity changes. You'll need patience and luck with the weather, of course – though the hardest part of this challenge may simply be staying up from midnight through to dawn on a cold, damp November night. With an observing window just shy of six hours, this is definitely one to wrap up warm for.

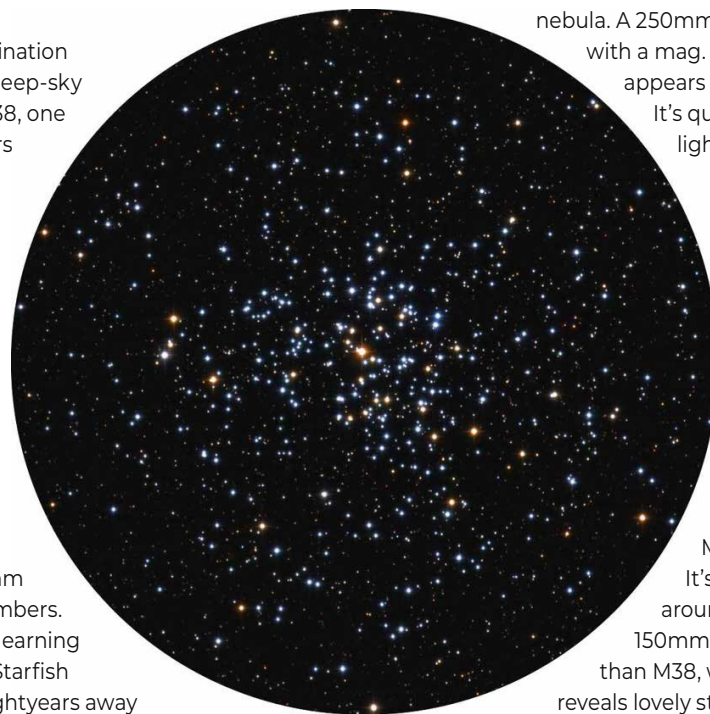
DEEP-SKY TOUR

Tour Auriga's finest clusters, including its famous Messier trio and lesser-known neighbours

1 M38



Auriga is a high-declination constellation full of deep-sky splendour. Our first target is M38, one of three famous Messier clusters within the constellation's misshapen pentagonal outline. It's easy to locate midway between mag. +2.7 Hassaleh (Iota (i) Aurigae) and mag. +2.6 Theta (θ) Aurigae (not shown). It's bright at mag. +6.4 and appears about 20 arcminutes across. A 150mm scope shows several dozen stars with many star strings. At low power, the cluster looks cross-like. Larger apertures increase the star count, a 250mm scope showing around 150 members. These strings photograph well, earning M38 the informal name of the Starfish Cluster. M38 lies about 3,480 lightyears away and is around 26 lightyears across. **SEEN IT**



nebula. A 250mm scope shows a diffuse glow with a mag. +11.5 central star. The nebula appears elongated northeast-southwest. It's quite a distant object at 7,500 lightyears away. **SEEN IT**

4 M36



We now head to the second of the Messier trio, M36. It lies about 1° east and a fraction south of NGC 1931, although a more robust route is to take a quick look at M38 again and head 2.2° southeast from there. The Messier trio are M36, M37 and M38, but they aren't in order; M36 lies between the other two. It's a lovely mag. +6.0 object around 12 arcminutes across. A 150mm scope shows a cluster less rich than M38, with about 60 stars. Low power reveals lovely star colours. A 250mm scope shows another 10–15 stars and a more centralised condensation than M38. M36 is about 4,300 lightyears away and 14 lightyears across. **SEEN IT**

2 NGC 1907



Open cluster NGC 1907 sits just 0.5° south of M38 and often gets overlooked in favour of its brighter neighbour. It has an integrated magnitude of +8.2 and an apparent diameter of 7 arcminutes, but even so is richly rewarding for smaller scopes, with about 30 members visible through a 150mm instrument. Larger apertures show the cluster nicely, adding another 10 or so stars to the view. A pair of mag. +9.7 and +9.9 stars sit 3 arcminutes southeast of the core, separated by 0.9 arcminutes. NGC 1907 sits 5,200 lightyears from Earth and has a radius of 12 lightyears. **SEEN IT**

▲ Last stop on the tour: M37's densely packed stars include a striking orange centrepiece

3 NGC 1931



Our next object is a young star cluster with an emission and reflection nebula. Head south from NGC 1907 by 50 arcminutes to arrive at a small group of stars that includes mag. +5.1 Phi (φ) Aurigae. These are part of a large asterism known as the Cheshire Cat. From Phi, head 0.7° (42 arcminutes) east-southeast to the area that contains the mag. +11.3 nebula NGC 1931. Once you're there, centre the target and increase to a medium-high power. A 150mm scope shows it as several stars and the

5 NGC 1893



Before we get to our final target, we'll backtrack slightly. Revisit Phi Aurigae, about 1.7° west and a fraction north of M36. M36 and M38 are like two end points of a three-pointed steering wheel, with Phi at the centre. The open cluster NGC 1893 is located where the third end point would be. This is a mag. +7.5 object around 12 arcminutes across. A 150mm scope shows around 30 stars, a figure boosted to around 50 through a 250mm instrument. This cluster is embedded in the emission nebula IC 410, an object that's hard to view visually, but photographically is known as the Tadpole Nebula, due to its shape. **SEEN IT**

6 M37



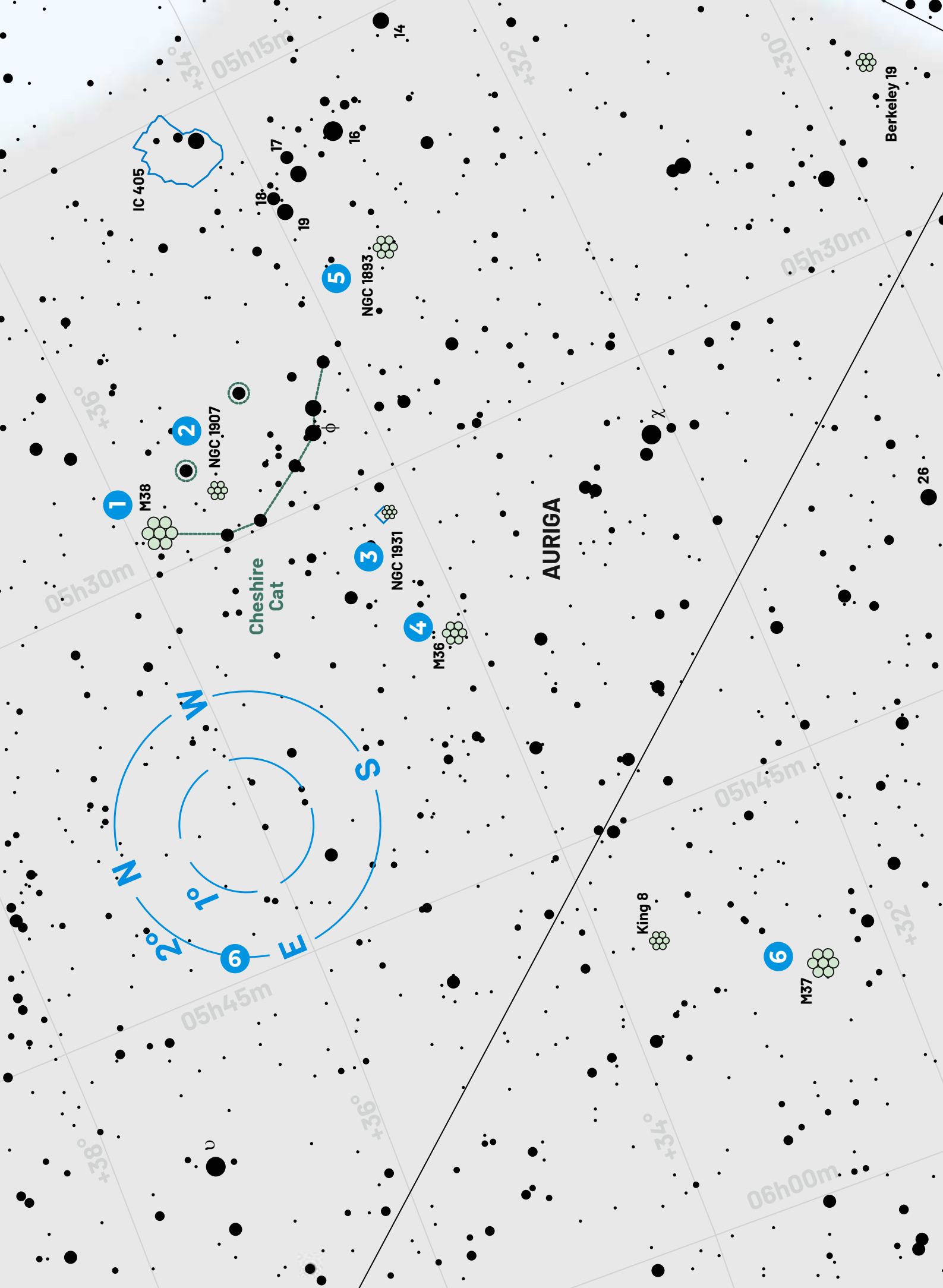
M37 is the last member of Auriga's Messier cluster trio. Known as the Salt and Pepper Cluster, it sits 3.7° east-southeast of M36. It's the brightest of the trio with an integrated magnitude of +5.6. This is a very rich object, highly condensed and a lovely sight through any telescope. A bright orange star sits in the centre, revealed well at low powers. Through a 150mm scope it looks more like a globular cluster, but an open cluster it is. The core is interesting, as closer inspection reveals it isn't uniform in shape, but rather shows a flat southeast boundary, outside of which is a darker space. M37 is around 4,500 lightyears distant and around 25 lightyears across. **SEEN IT**

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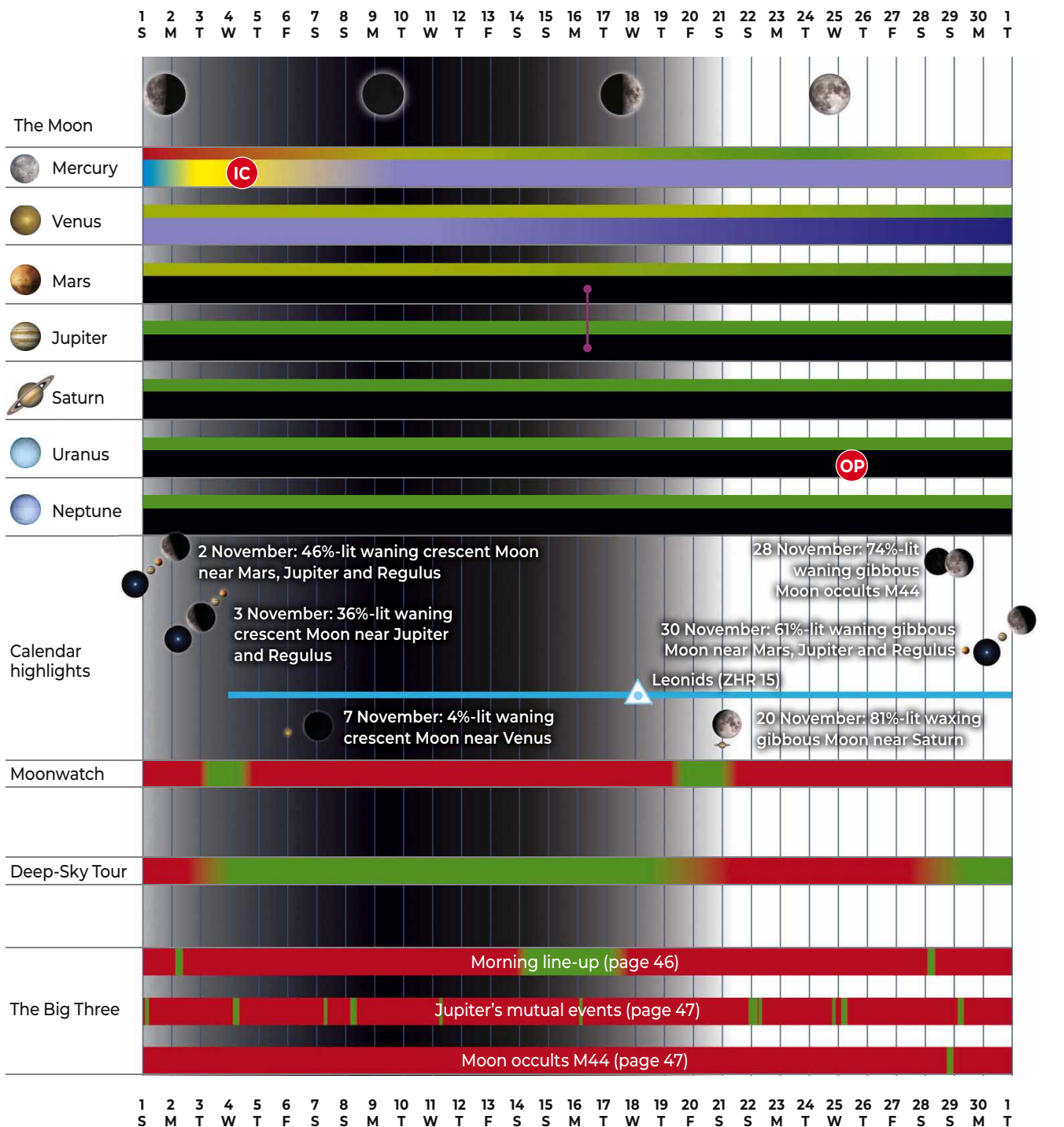
This Deep-Sky Tour has been automated. ASCOM-enabled Go-To mounts can take you to this month's targets at the touch of a button. Find the Deep-Sky Tour file in our free Bonus Content online.





AT A GLANCE

How the Sky Guide events will appear in November



KEY

Observability



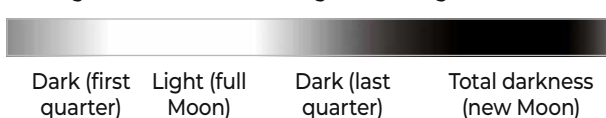
Optimal Fair Poor

Best viewed



Morning twilight Daytime Evening twilight Deep twilight Night

Sky brightness during lunar phases



Dark (first quarter) Light (full Moon) Dark (last quarter) Total darkness (new Moon)

IC

Inferior conjunction (Mercury & Venus only)

SC

Superior conjunction

OP

Planet at opposition

▲

Meteor radiant peak

⋮

Planets in conjunction



Full Moon



First quarter



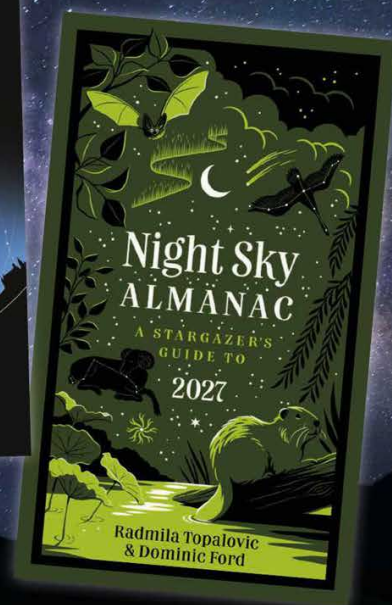
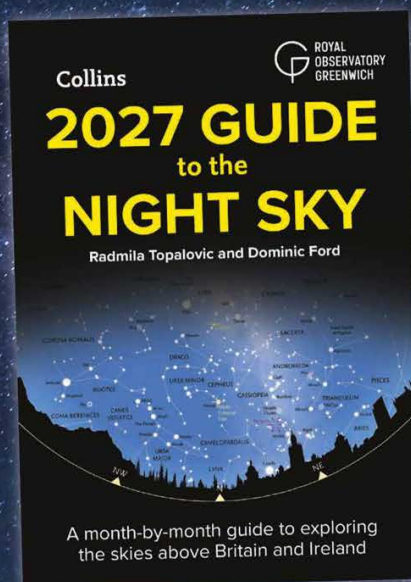
Last quarter



New Moon

From the
number 1
Astronomy
publisher

THE PERFECT GIFTS FOR AMATEUR AND SEASONED ASTRONOMERS



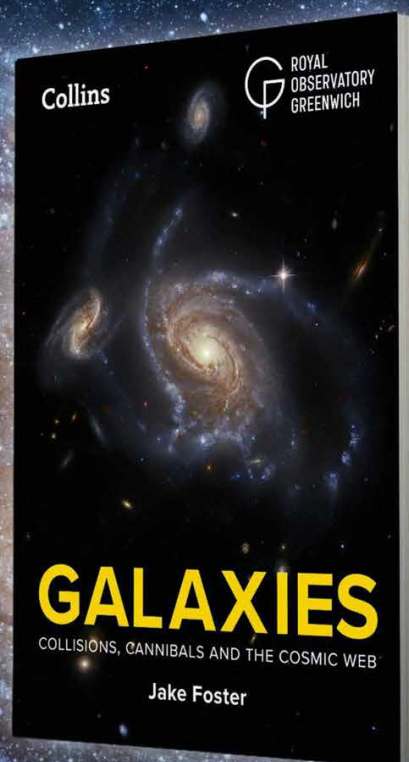
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A BEGINNER'S GUIDE TO THE GALAXIES IN OUR UNIVERSE

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Unravelling **MERCURY'S MYSTERIES**

After an eight-year journey, BepiColombo is finally set to enter orbit around the Solar System's smallest, innermost planet.

Govert Schilling looks at what secrets the mission could reveal

It's small. It's dense. It's hot. But most of all, the innermost planet in our Solar System is mysterious. So far, tiny Mercury, the first rock from the Sun, has only been visited by two spacecraft – far fewer than have explored Mars, Venus or even Jupiter. But things are about to change.

On 21 November, after an eight-year journey, the European/Japanese BepiColombo mission will finally enter orbit around this crater-covered world, studying its fascinating geology and

feeble magnetic field. "There's still a huge amount to be learned," says lead project scientist Geraint Jones.

Chances are that you've never actually seen Mercury. If so, you're in good company. Rumour has it that famous 16th-century Polish astronomer Nicolaus Copernicus also never set eyes on the planet. That's because Mercury's 88-day path around the Sun lies well inside Earth's orbit, so from our vantage point, it always appears close to the Sun in the sky and often hidden in its glare.

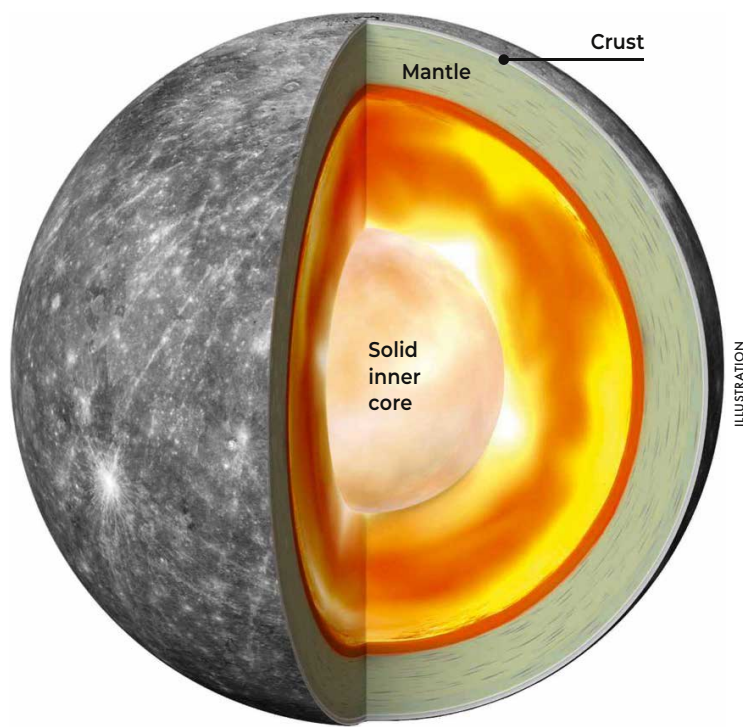
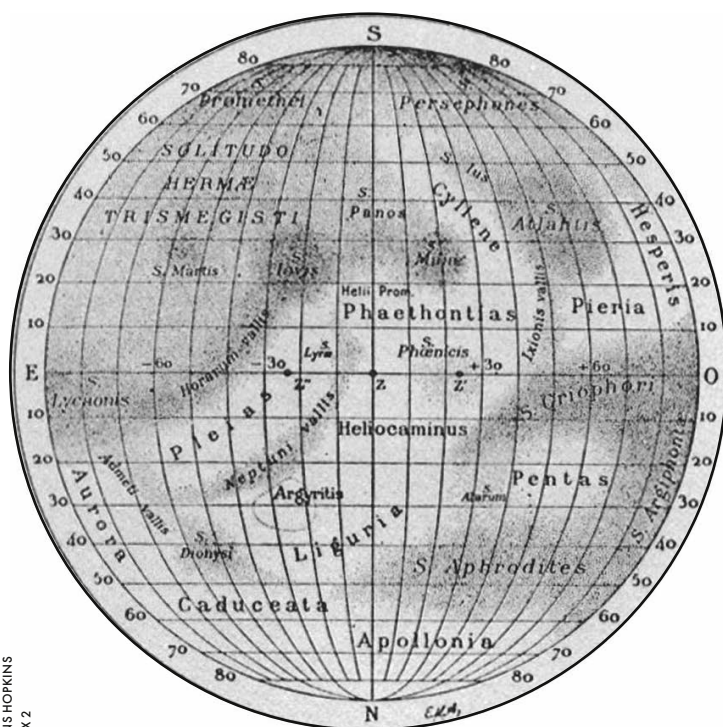
But although it can only be seen during dusk or dawn, the fast-moving planet was known to Babylonian astrologers thousands of years ago. The Romans named it Mercury after their winged messenger-god, known to the Greeks as Hermes. In 1612, German astronomer Simon Marius used a homemade telescope to discover the planet's Moon-like phases, the result of its varying illumination by the Sun.

Ever since the start of the 19th century, keen-eyed astronomers have tried to ►

ILLUSTRATION: SPACECRAFT: ESA, ATG/MEDIA/LAB; MERCURY: NASA, JPL



Scorchingly hot, hard-to-reach Mercury has long been an enigma. Now BepiColombo is poised to lift the lid on this tiny world



► discern surface details on little Mercury, which is just 4,880km (3,030 miles) in diameter. In the 1930s, Greek astronomer Eugène Antoniadi even drew up maps of the planet, showing dark and bright regions that led him to believe Mercury always keeps one side directed to the Sun, similar to the so-called synchronous rotation of the Moon around Earth.

Mercury: what we know

In the early 1960s, all our knowledge of Mercury fitted easily on a beer mat, and some was outright wrong. That became evident in 1965, when radar observations from Earth revealed something startling: the planet completes just three rotations around its axis for every two orbits around the Sun. As a result, every point on the planet's surface

experiences 88 days of bright daylight followed by 88 days of utter darkness, with temperatures ranging between -170°C and $+430^{\circ}\text{C}$ (-274°F to $+806^{\circ}\text{F}$).

More surprises came in 1974 and 1975, when NASA's Mariner 10 spacecraft completed three close approaches to the planet while orbiting the Sun. By studying the precise way in which the craft's orbit was deflected by Mercury's gravity, researchers discovered that the planet harbours a huge metallic core. It measures some 4,000km (2,485 miles) across and takes up a staggering 57 per cent of Mercury's volume, compared to 17 per cent in the case of Earth's core. Mariner 10 also detected a global magnetic field, albeit very weak, which is probably generated in the partially melted core.

▲ Left: Eugène Antoniadi mapped dusky markings on Mercury, mistakenly concluding the planet was tidally locked to the Sun

Right: the planet's solid metallic core was confirmed by Mariner 10 in the 1970s

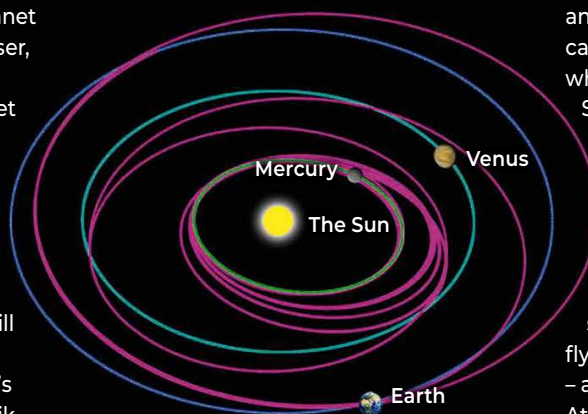
Slow road to Mercury

Why BepiColombo needed eight years, ion engines and nine fly-bys to reach its target

Most of the time, Mercury is the planet closest to Earth (Venus can get closer, but only occasionally). So why did BepiColombo take eight years to get there? It's all to do with gravity.

For a spacecraft to reach Mercury, it has to follow an elliptical path that starts at Earth and eventually takes it much closer to the Sun. As it falls into the Sun's gravitational well, the craft will end up moving faster and faster.

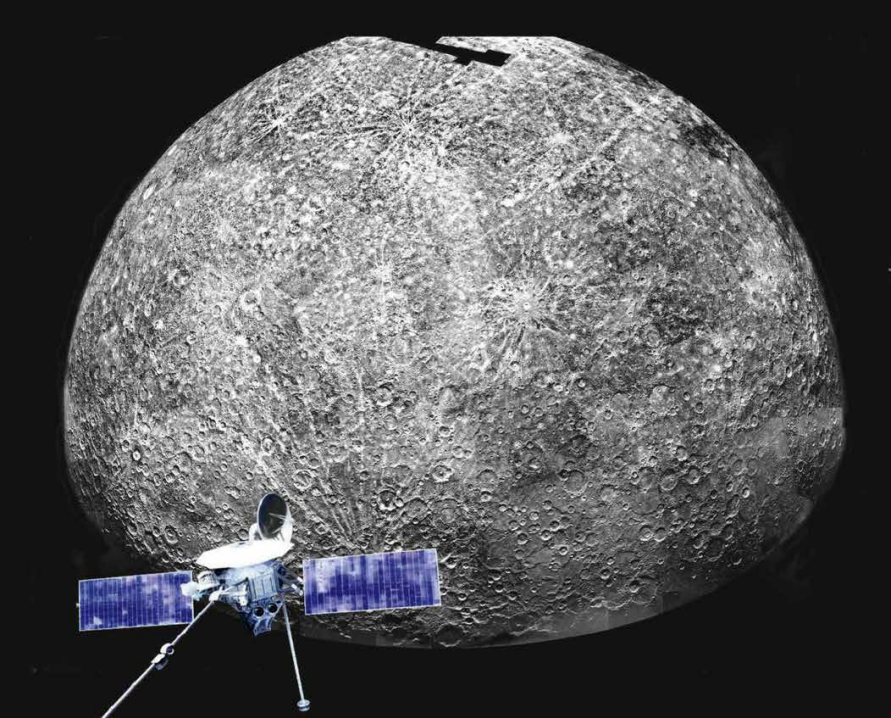
"But to enter orbit," explains ESA's flight dynamics expert Frank Budnik, "BepiColombo has to move at almost the same velocity as Mercury." If it didn't, it would just zip past the planet at high speed. Mercury's small mass



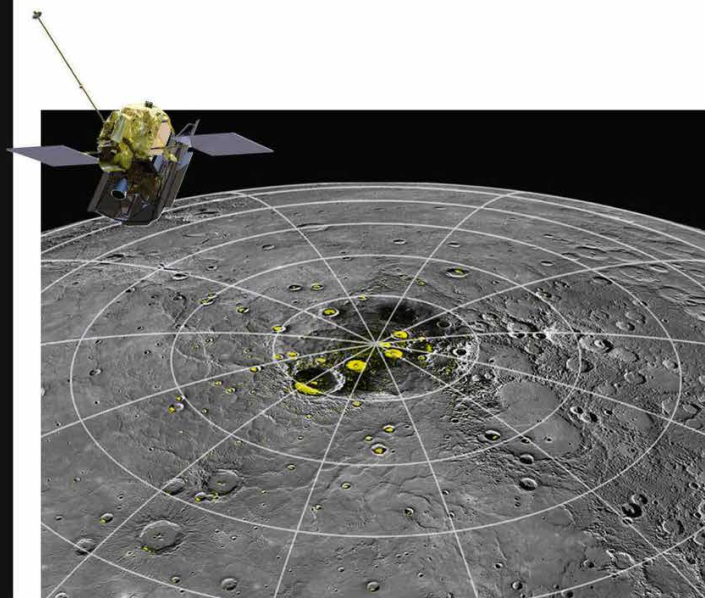
▲ To reach the Solar System's innermost planet, BepiColombo had to complete a complex series of manoeuvres around Earth, Venus and Mercury itself

and weak gravity mean it can only capture a spacecraft into its orbit when the relative velocity is very low. So BepiColombo had to slow down significantly.

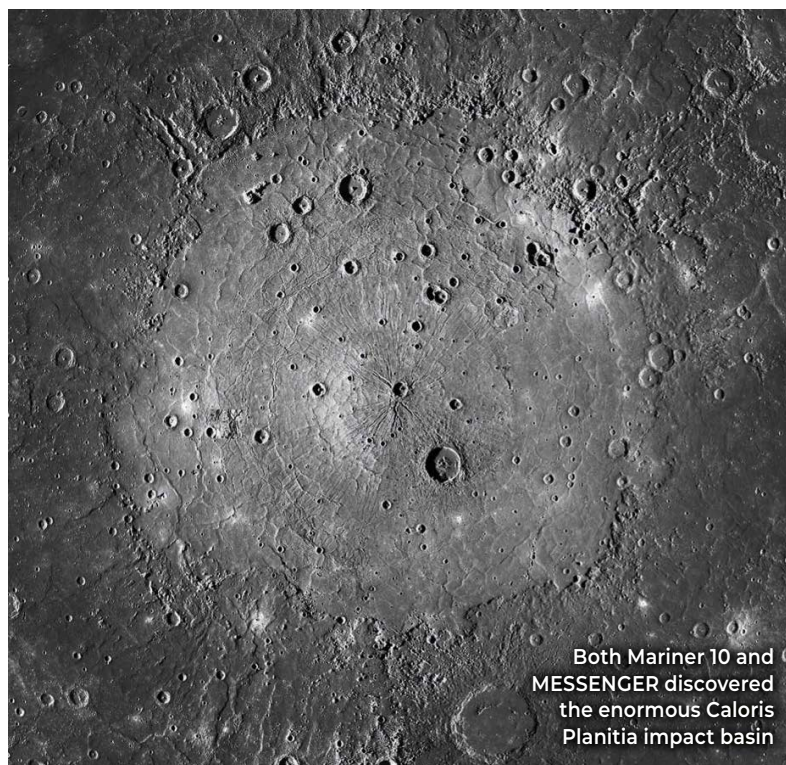
Instead of burning a massive load of rocket fuel, which would have made the launch extremely costly, engineers chose to slow the craft using a solar electric propulsion system and nine time-consuming fly-bys of Earth, Venus and Mercury itself – a technique known as a gravity assist. At each swing-by, the planets' gravity put the brakes on the spacecraft and helped steer it into Mercury's orbit. As a last step, small thrusters will manoeuvre the probe into its final orbit.



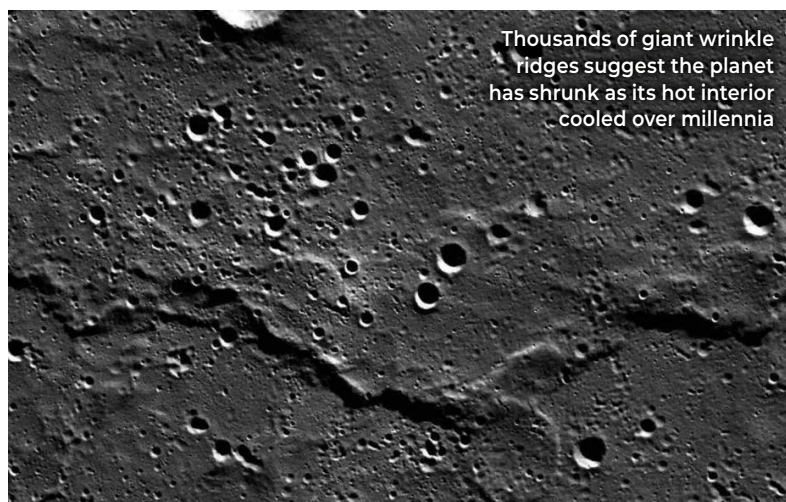
▲ Mariner 10 (inset) mapped 45 per cent of Mercury's surface, uncovering its Moon-like appearance, thin atmosphere and weak magnetism



▲ MESSENGER's spectroscopy and laser altimetry confirmed ice deposits in craters at the poles



Both Mariner 10 and MESSENGER discovered the enormous Caloris Planitia impact basin



Thousands of giant wrinkle ridges suggest the planet has shrunk as its hot interior cooled over millennia

According to Jones, the origin of Mercury's large core is still an unsolved mystery. One popular explanation holds that the planet was born much larger than it is now, and that a catastrophic collision with another planetary body flung most of its rocky mantle into space, leaving the original iron-rich core with a relatively thin silicate mantle. "New data from BepiColombo will hopefully show us how well this theory holds," says Jones.

NASA's second Mercury mission, MESSENGER (a convoluted acronym of MErcury Surface, Space ENvironment, GEochemistry, and Ranging) launched in August 2004, and in March 2011 became the first craft to orbit the planet. For four years, it mapped the whole surface (Mariner 10 had only photographed some 45 per cent) and studied its chemical composition. Its instruments also confirmed the presence of ice deposits in permanently shadowed craters close to the planet's poles, first suggested by terrestrial radar observations in the early 1990s.

A world of scars and hollows

Mercury's heavily cratered surface strongly resembles the Moon's, but there are important differences. The planet lacks the large, relatively crater-free lava plains that dominate the near side of the Moon, although geologists have found numerous traces of ancient volcanism, including pyroclastic flows. Sinuous compression faults (sometimes known as 'wrinkle ridges') tens of kilometres long and up to a few kilometres high indicate that the planet has shrunk in on itself by a few kilometres as it cooled down over the aeons.

Apart from countless craters, almost all of which are named after painters, composers and other artists, Mercury sports dozens of large impact basins, including 1,550km-wide (960-mile) Caloris Planitia, one of the largest impact structures in the Solar System. MESSENGER also found mysterious sinkhole-like 'hollows' that likely formed when volatile compounds sublimated under fierce sunlight. "It's as if the surface has literally been ►

► eaten away,” says Jones. “The hollows are a unique feature to Mercury.”

Because of its high temperature and low surface gravity (just 38 per cent that found on Earth), Mercury is unable to hold onto much of an atmosphere. Instead, it is surrounded by an extremely tenuous, extended exosphere. This is made up of hydrogen and helium atoms temporarily captured from the solar wind by the planet’s feeble gravity, and heavier atoms from the surface, including oxygen, sodium and calcium, released by meteorite impacts.

Mercury’s magnetic field, which is around 100 times weaker than Earth’s, still manages to capture charged particles from the Sun to create a relatively tiny magnetosphere, although it’s unable to protect its surface from an intense bombardment of solar wind and cosmic rays in the way that Earth’s does.

Two missions in one

BepiColombo, a joint project of the European Space Agency (ESA) and the Japanese space agency JAXA, is humanity’s third mission to Mercury. Selected by ESA in 2000 as the last highlight of the agency’s Horizon 2000+ programme, the 4,100kg (9,040lb) spacecraft was launched on 20 October 2018, on a European Ariane 5 rocket. Before arriving at Mercury, it made one swing-by of Earth, two of Venus and six of Mercury itself – the last one in January 2025.



Eaten away: the planet is dappled with strange hollows unlike any seen elsewhere in the Universe

The Mercury fly-bys have already yielded many scientifically interesting results, including high-resolution imagery of the planet’s north pole.

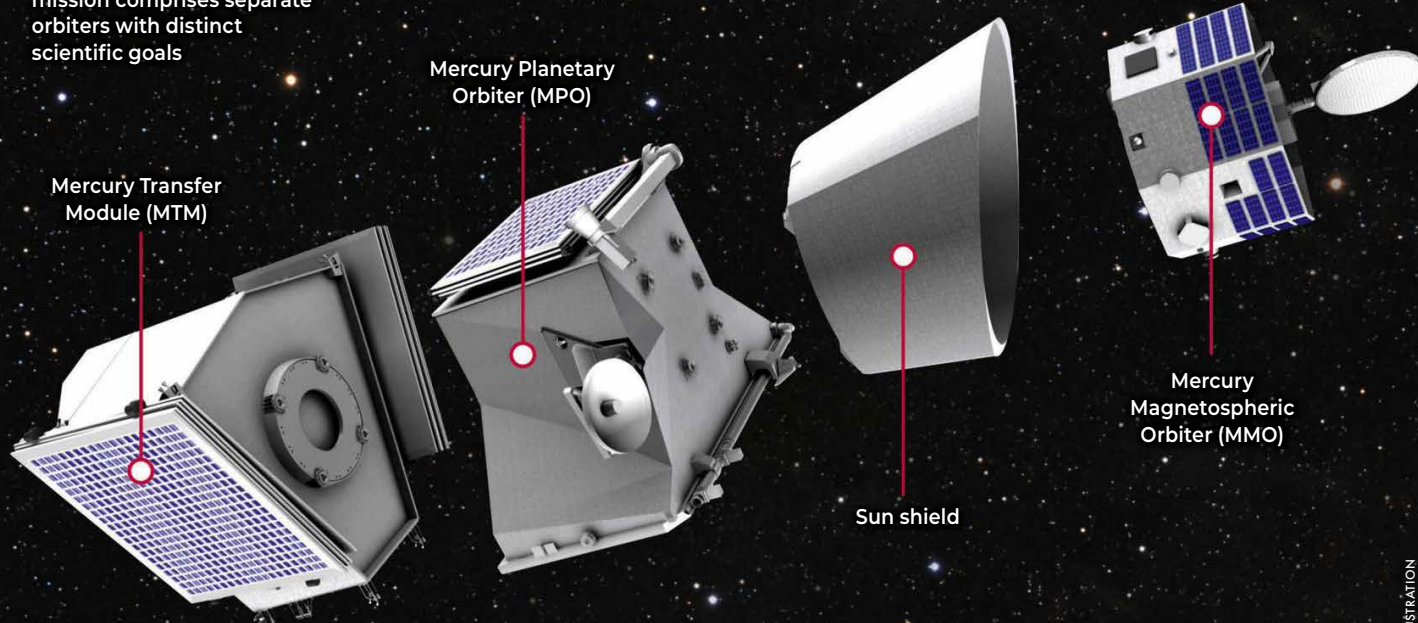
What makes BepiColombo special is that it’s really two missions for the price of one. “It’s the first time we’ll deliver two separate probes in orbit around Mercury,” says mission manager Santa Martinez. The largest is the Mercury Planetary Orbiter (MPO), built by ESA and outfitted with a suite of 11 science instruments to study the planet’s surface and geology from a low 2.3-hour polar orbit. Apart from a high-resolution camera, these include a laser altimeter to precisely map Mercury’s topography, and an X-ray spectrometer to measure the chemical composition of the planet’s surface.

Meanwhile, a thorough study of Mercury’s magnetic field and plasma environment is the main goal of the Mercury Magnetospheric Orbiter (MMO), nicknamed Mio. Mio is the Japanese part of the mission, although its magnetometer instrument was built in Austria. The small octagonal craft also carries a dust monitor. Mio will take 9.3 hours to complete



Govert Schilling’s latest book *The Astronomy Handbook* is published by Black Dog & Leventhal

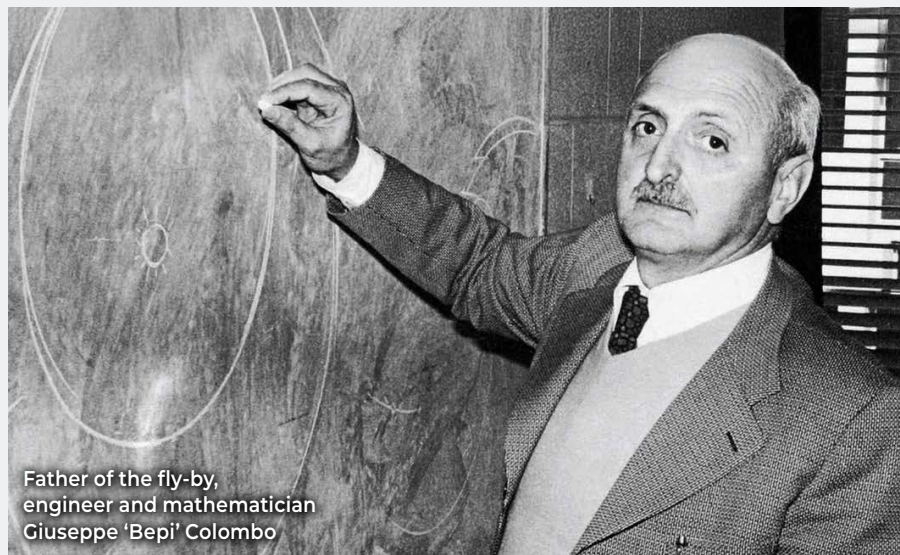
BepiColombo’s two-for-one mission comprises separate orbiters with distinct scientific goals



ILLUSTRATION

The pioneer behind the name

Meet the Italian mathematician whose genius with orbits enabled missions to Mercury and beyond



Father of the fly-by,
engineer and mathematician
Giuseppe 'Bepi' Colombo

Professor Giuseppe Colombo (1920–1984), affectionately known as Bepi (pronounced 'beppe'), was an Italian mathematician and engineer at the University of Padua. In 1965, he explained Mercury's remarkable spin-orbit

resonance: for every two orbits around the Sun, the planet rotates three times. Mercury's elongated, or 'eccentric', orbit makes the Sun's tidal pull strongest at just the right points, helping to lock this pattern into a stable state.

Colombo also pioneered the use of gravity-assist manoeuvres for interplanetary missions, when a close planetary encounter changes a spacecraft's orbit, both in terms of orientation and velocity. This 'slingshot technique' (which can either accelerate or decelerate a spacecraft) was applied for the very first time by Mariner 10 in 1974. Its three Mercury fly-bys wouldn't have been possible without a preceding gravity assist from Venus that slowed down the craft significantly.

Gravity assists went on to play an essential part in the multi-planet missions of the Voyager spacecraft, and indeed have become an important element of almost all planetary missions, including Colombo's own eponymous Mercury mission.

As well as that mission to uncover the mysteries of Mercury, the Colombo Gap in Saturn's inner C Ring and the asteroid 10387 Bepicolombo are both named in honour of the space pioneer.



The journey is almost over.
BepiColombo's two craft
will separate and begin
operations in early 2027

its much larger, elliptical orbit. On 3 September, a spring mechanism successfully released the dual spacecraft from the Mercury Transfer Module (MTM) that had transported BepiColombo all the way to Mercury. Ignacio Tanco, ESA's head of inner Solar

System mission operations, described that critical milestone as "the launch of a new spacecraft". Still attached to each other, MPO and Mio will be captured into a highly elliptical polar orbit around Mercury on 21 November.

Arrival at last

After the two orbiters separate, on 9 or 10 December, the European one will be slowly manoeuvred into its final orbit, which it will reach on 10 March next year. Regular science operations, from altitudes between 480km and 1,500km (300–930 miles) are set to commence on 6 April and last for at least one year, with a possible extension to late 2029.

Planetary scientists expect BepiColombo to teach them much more about the behaviour of an airless, rocky, magnetised planet so close to its parent star. One of the things Jones is interested in is the response of the magnetosphere to explosions on the Sun and to meteorite impacts on the planet's surface. "Having two spacecraft working simultaneously will help enormously," he says.

But he also looks forward to learning more about the polar ice deposits, the weird hollows, the interior composition of the overly dense planet, and its complex geologic history. "Mercury is the least understood of the four terrestrial planets," Jones comments. Hopefully, BepiColombo is going to solve many of the planet's outstanding mysteries. 🌟



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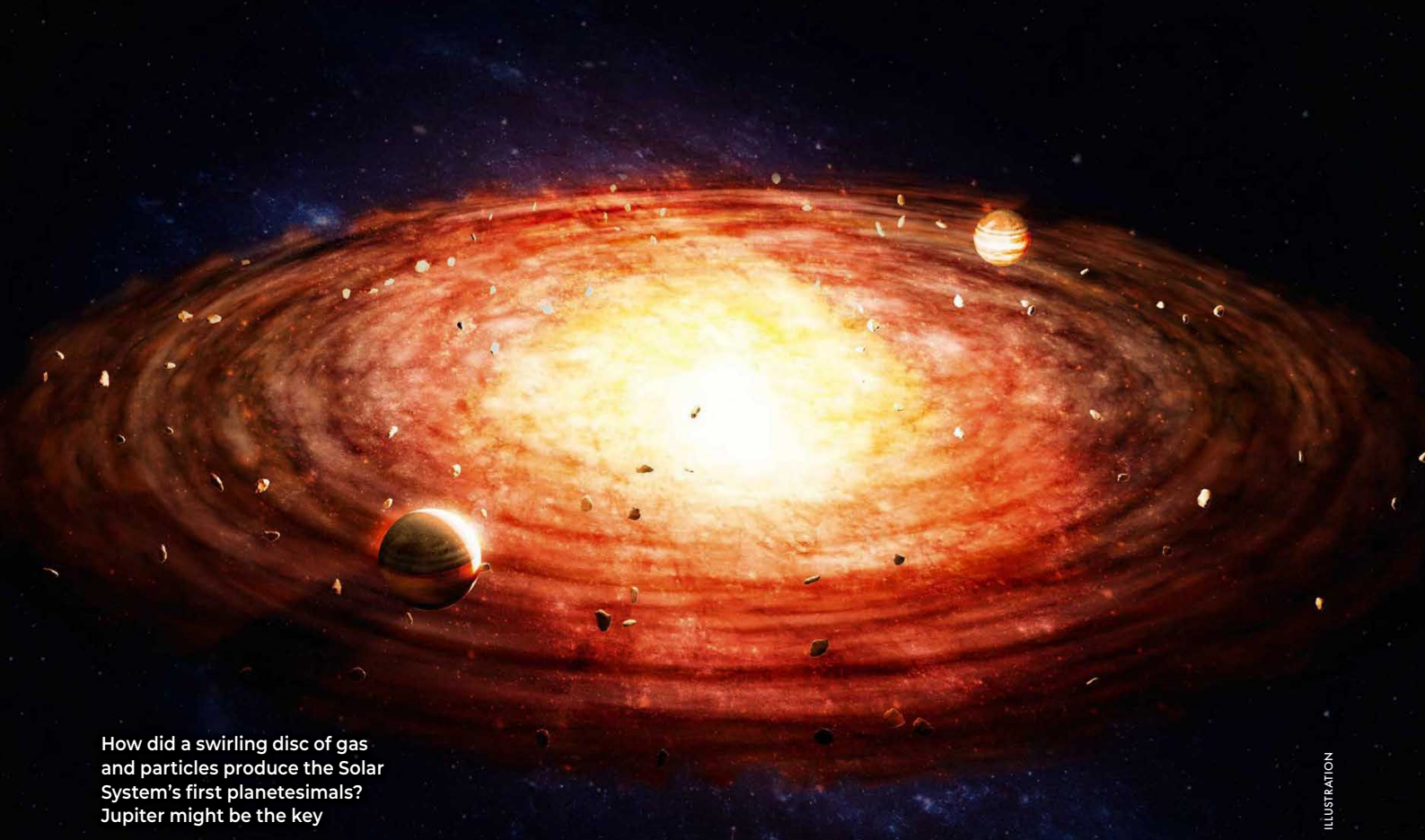
JUPITER

the planet creator

Joseph Phelan explores new evidence suggesting that the Solar System's largest planet was pivotal in forming its other worlds

RICK GAILMARK

Did Jupiter once preside over a vast 'planetesimal factory' that ultimately birthed the Solar System's planets and moons?



How did a swirling disc of gas and particles produce the Solar System's first planetesimals? Jupiter might be the key

ILLUSTRATION

Our Solar System emerged from a disc of gas and dust that once surrounded the newborn Sun. From this material came the first solid bodies that would go on to form planets, moons and asteroids. But exactly how those minuscule grains of material came together to form the very first planetesimals – the small celestial bodies that provide the raw material for larger worlds – remains one of astronomy's biggest unresolved problems.

Now a study published in *The Astrophysical Journal* suggests that part of the answer may lie in a remarkably productive ring of dust that once orbited just beyond Jupiter.

Researchers at the Max Planck Institute for Solar System Research (MPS) in Germany have used computer simulations to show that such a ring could have behaved as a long-lived 'planetesimal factory', churning out generation after generation of rocky building blocks, each batch chemically distinct from the last, over the span of roughly two million years.

The findings offer a fascinating insight into the possible origins of planets, including Earth, and how some of the Solar System's earliest solid bodies may have formed.

The pebble problem

Nearly all young stars are surrounded by a disc made up largely of gas, along with dust and larger solid particles. The gas is supported partly by its internal pressure, meaning it generally orbits the star slightly more slowly than the solid particles do.

This difference in speed can create drag on the dust and larger 'pebbles', causing them to lose angular momentum and spiral inwards into the star. This process, known as radial drift, can remove

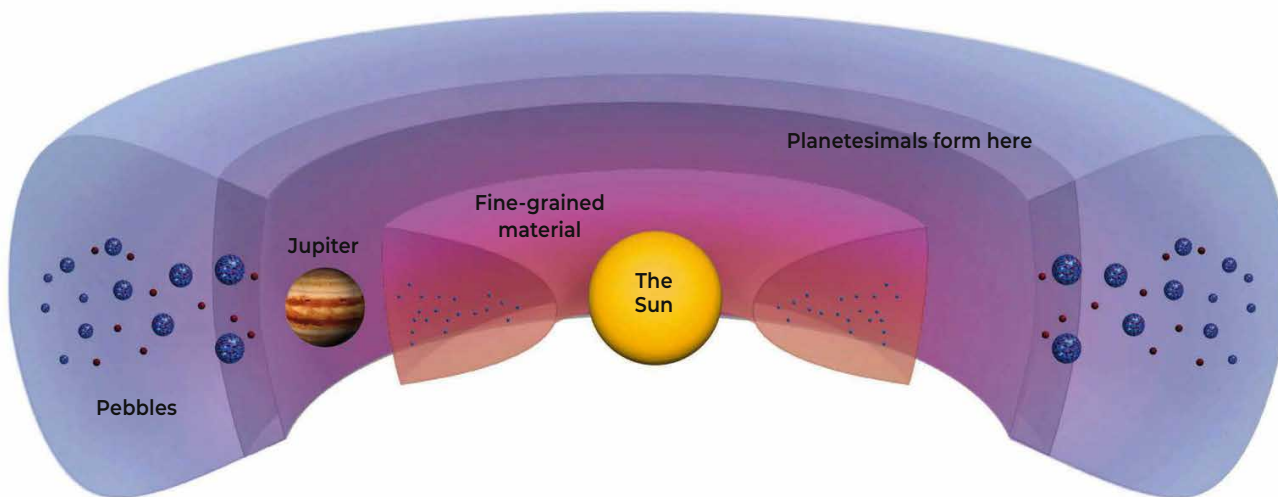


▲ **Fledgling planets face a big challenge: keeping pebbles together long enough to become something bigger**

solid material from the disc before it has time to accumulate into larger bodies, and presents a fundamental barrier to the development of planetary systems. But radial drift is not the only obstacle to planet creation: there is also the question of how loose pebbles come together into something solid in the first place.

"The most plausible hypothesis is that planetesimal formation involves the gravitational collapse of clouds of pebbles," explains Philip Armitage, professor of physics and astronomy at Stony Brook University. "That's a threshold process that's not just less efficient if the abundance of pebbles is lower; rather, it doesn't occur at all."

In other words, a cloud of pebbles has to reach a certain density before its own gravity can draw it together into a planetesimal. This creates two linked problems: the pebbles need to stay in the disc rather than drifting towards the star, and they need



to become concentrated enough for planetesimal formation to occur.

What is known as a 'dust trap' could help solve both of these issues. This is a region in a young star's gaseous disc where the gas pressure reaches a local high point, causing drifting dust and pebbles to collect, rather than continuing inwards. In these regions, more material can gather, and the concentration of pebbles can eventually become high enough for gravity to bring them together and form planetesimals.

The researchers argue that this is where Jupiter could have played a crucial role.

The making of a planet factory

In the MPS model, as Jupiter grew, its gravity disturbed the surrounding gas and opened a gap in the disc. Outside that gap, gas accumulated, creating a region of higher pressure. It is thought that this 'pressure bump' could then have acted

▲ **Beyond a growing Jupiter, drifting pebbles may have collected in a dense ring, a 'dust trap' that produced rocky building blocks**

as a dust trap, slowing down the inward drift of pebbles and causing them to accumulate beyond Jupiter's orbit.

"A dusty ring that is caused by a giant planet, as in this case, is thought to be very stable," says Armitage. "The planet's gravity creates a gap in the gas disc, and that's almost the only prerequisite for accumulating dust in the ring, exterior to the planet."

As pebbles gathered in this sheltered region, their density may have eventually become high enough for gravity to take over.

"This study demonstrates that millimetre-sized pebbles trapped outside the orbit of Jupiter could have reached high enough concentrations to trigger streaming instability [the next stage of planetesimal formation – an aerodynamic process where gas and solid dust pebbles interact] and form planetesimals there," explains Anders Johansen, a planetary science professor at the Centre for Star and Planet Formation at the University of Copenhagen. ►

Jupiter: the Solar System's gatekeeper

While the young Jupiter may have helped build the planets, it now plays a very different role in their fate

With its colossal mass, Jupiter has a powerful gravitational pull that can capture, deflect and send objects hurtling into interstellar space, altering the paths of bodies that might otherwise enter the inner Solar System. However, its influence works both ways: while it can act as a protector, its gravity can also redirect objects toward planets.

The outcome depends largely on where an object originates. Simulations suggest that Jupiter acts as an effective shield against long-period comets arriving from the distant Oort cloud,

which is located beyond Pluto and the Kuiper Belt. The King of Planets can intercept these icy bodies before they reach the inner planets, hurling them towards the outer reaches of the Solar System.

For main-belt asteroids and short-period comets, however, Jupiter's influence can have the opposite effect. By disturbing their orbits, the giant planet actually increases the number of objects reaching the inner Solar System, raising Earth's collision risk far above what it would be in a system without a giant planet.

Jupiter, then, is neither a simple shield nor a cosmic menace. Instead, it acts as a gravitational gatekeeper shaping the routes of smaller bodies, keeping some threats at bay but sometimes putting Earth in harm's way.

◀ Nice save? Jupiter deflects inbound comets – but not always in the right direction

ILLUSTRATION



► Scientists have long suggested that dust traps could have helped to form planetesimals, but less clear was whether a single trap could continue to produce them for millions of years. The MPS team's simulations, which modelled the interval between roughly two and four million years after the Solar System formed, indicate that it could.

Their models followed two types of solid material: fine, fragile dust and larger, sturdier particles that had formed earlier in the hotter inner disc before moving outwards. The researchers tracked how these particles collided, stuck together, broke apart, drifted through the disc and became trapped.

But Jupiter's pressure bump did not trap the two types of material equally. Larger, sturdier particles were retained more effectively than the finer dust, and newly formed planetesimals also continually removed material from the ring.

These two effects appeared to change the balance between the materials over time. During the first 500,000 years, the proportion of fine dust

▲ The diversity seen in chondritic meteorites hints that Jupiter's dust trap produced distinctly different planetesimals over time

fell, before increasing again over the following million years. Planetesimals forming at different points in this period would therefore have contained different mixtures of the two materials.

The outcome was two distinct populations of planetesimals: some

dominated by fragile dust and others containing a larger proportion of the sturdier particles. In other words, the same dust trap could well have produced different types of planetesimals across different stages of its lifetime.

A match in the meteorites

Crucially, these simulations can be tested against physical evidence preserved in meteorites. "Chondritic meteorites are important time capsules left over from the formation of the Solar System. In the absence of any data from these meteorites, models for the formation of these bodies could produce any number of outcomes," notes Fred Ciesla, professor and chair of geophysical sciences at the University of Chicago.

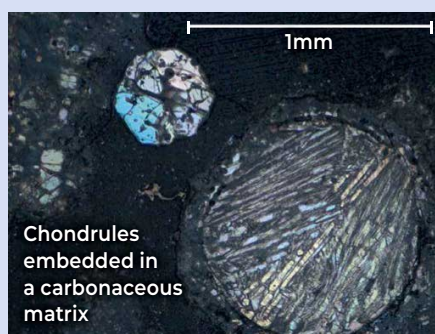
Because their parent bodies never underwent extensive melting, chondritic meteorites preserve a record of the grains that came together to form them more than 4.5 billion years ago. That makes them an incredibly useful way to test models of planet

Meteorites: time capsules of planet formation

These ancient rock fragments hold clues to the conditions found in the forming Solar System

Meteorites are fragments of asteroids and other bodies that formed early in the Solar System. Some have survived largely unchanged for billions of years, preserving a record of the conditions in which they formed. Among the most scientifically valuable are carbonaceous chondrites, primitive, carbon-rich meteorites that preserve some of the Solar System's oldest material.

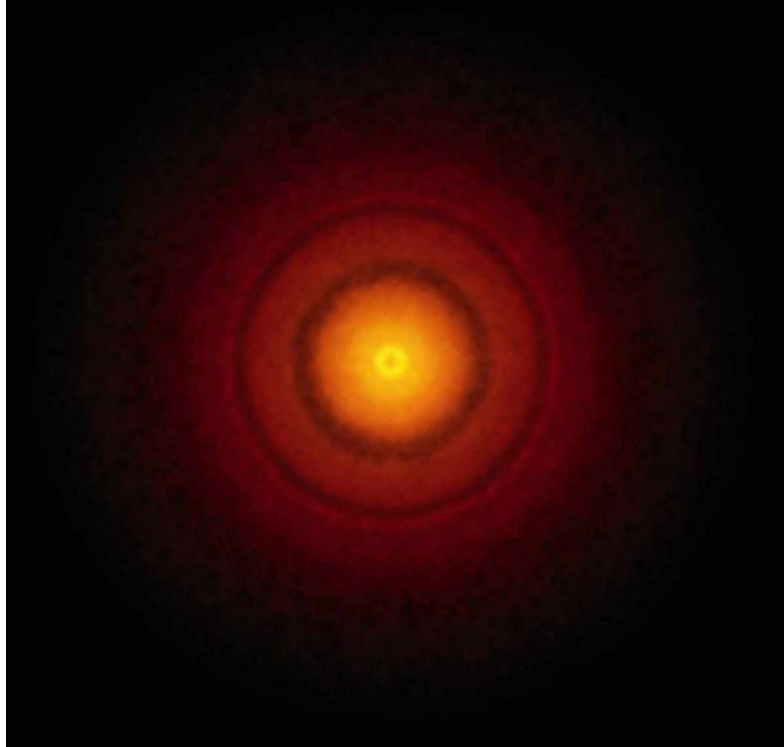
Under a microscope, carbonaceous chondrites contain a mixture of fine-grained dust and larger, rounded particles. The dark, fine-grained material is known as the matrix, while the larger structures include chondrules, which



formed as droplets of molten rock, and calcium-aluminium-rich inclusions (CAIs). CAIs are some of the oldest solid materials known from the Solar System

and formed at very high temperatures near the young Sun.

Carbonaceous chondrites are divided into several groups based on their chemistry and composition. Their differences reflect the conditions in which their parent asteroids formed and the material available to them as they grew. By studying the proportions and properties of the materials inside them, scientists can piece together when and where these asteroids formed, and how conditions varied across the young Solar System. This provides evidence that can be used to test models of how planets and other bodies eventually developed.



Did some of the bodies produced beyond Jupiter carry water and prebiotic ingredients to Earth?

ILLUSTRATION

formation. “By linking the data collected from various measurements of meteorites with model outcomes, we’re narrowing down the range of conditions and processes that were present,” Ciesla adds.

The MPS team focused on carbonaceous chondrites, carbon-rich meteorites divided into six groups based on their age and composition. In the simulations, the changing balance of fragile dust and sturdier material produced different types of planetesimals, and their compositions closely matched those of the different carbonaceous chondrite groups found in meteorites.

For Til Birnstiel, a professor of theoretical astrophysics at Ludwig Maximilian University of Munich, this makes the model’s findings particularly significant: “It demonstrates quantitatively that this physical picture can explain not only how asteroids form, but also how several very different types of carbonaceous chondrites could have emerged out of the same planetesimal factory.”

A common story?

If a dust trap just outside Jupiter’s orbit really did help produce these planetesimals, similar processes could conceivably occur – and may currently be occurring – around other young stars.

Since the ALMA Observatory in Chile began operating, observations have shown that “rings, gaps and other dust concentrations appear to be extremely common,” says Birnstiel. And Armitage agrees: “There are at least a couple of young stars with discs where similar structures can be directly imaged, and they’re likely commonplace.”

The MPS research also raises questions about Jupiter’s wider role in the early Solar System. Carbonaceous chondrites have been linked to the delivery of water and prebiotic molecules to Earth, meaning that the way these bodies formed may have influenced the conditions on our planet. “Without Jupiter, we’d likely be looking at a very, very different planetary system,” says Ciesla.

However, the existence of a Jupiter dust trap cannot explain the formation of every planetesimal.

▲ Rings and gaps in other stars’ protoplanetary discs suggest that dust-trapping rings could be the norm



Joseph Phelan is a journalist who has written for *National Geographic*, *BBC Science Focus* and *BBC Wildlife*

“Planetesimals must also have formed prior to the emergence of Jupiter,” explains Johansen. “It raises a chicken-and-egg problem if planetesimals are needed to form planets, and planets are needed to form planetesimals. There must have been other pathways to form planetesimals before the emergence of the giant planets.”

He suspects the water-ice line may have been one such pathway. In these regions, dust grains and icy particles could have become concentrated enough to trigger streaming instability.

Yet Jupiter’s role as the Solar System’s planetary architect is still far from fully understood. How did Jupiter itself form and grow quickly enough to separate material from the inner and outer Solar System? To what extent did it influence the flow of pebbles that eventually helped build the terrestrial planets Earth, Mars, Mercury and Venus? The new MPS study may help explain one stage of that early history, but the story of how our Solar System assembled is still far from complete. 🌀



But how did the giant planet itself emerge so early? Jupiter has yet to give up all its secrets

ILLUSTRATION

The fundamentals of astronomy for beginners

EXPLAINER

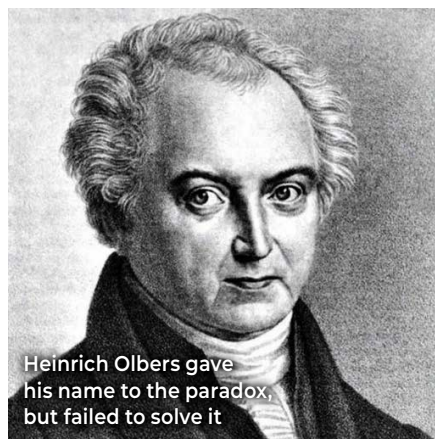
We all know the stars shine against a dark sky, but the reason puzzled astronomers for centuries

Why is the sky dark?

The Universe contains countless stars, each pouring out light. So why isn't the whole night sky ablaze? Welcome to Olbers' paradox

Have you ever seen a starry night sky? There are stars, and between them there is darkness. That's hardly surprising. It's nighttime, after all. Yet that darkness presents one of the oldest problems in astronomy – and its answer turns out to be one of the most important things we have discovered about the Universe.

Suppose the Universe is infinite: it has always existed and its stars are scattered pretty evenly throughout it. Now pick any direction and follow your line of sight outwards. Sooner or later, it must land on the surface of a star. It might take an unimaginable distance, but in an infinite Universe there is always another star farther out. Every point in the sky should contain a star, and the whole



Heinrich Olbers gave his name to the paradox, but failed to solve it

sky, night included, should therefore be extraordinarily bright like the surface of the Sun.

It is the same effect you'd get if you stood in the middle of a vast forest with

a very large number of trees. No matter where you looked, you'd only see trunks.

Where's all the starlight?

The night sky, of course, is the opposite of bright. That contradiction is what we call Olbers' paradox, named after the German astronomer Heinrich Wilhelm Olbers, whose scientific paper first described the problem in 1823.

It was, however, a long-standing conundrum, having previously been discussed by Thomas Digges in 1576, Johannes Kepler in 1610 (who even interpreted the dark sky as evidence that the Universe must have an edge), and both Edmond Halley and Jean-Philippe Loys de Chéseaux during the 1700s.

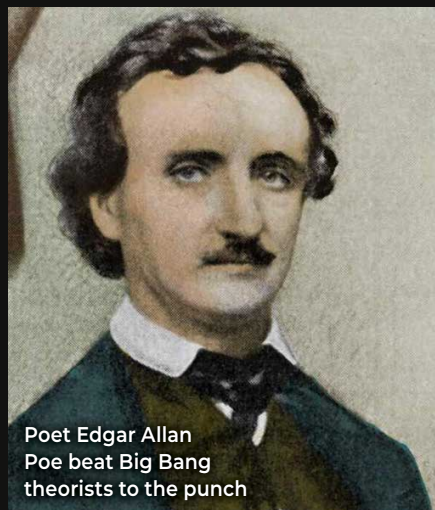
Yet Olbers got his explanation wrong. He proposed that clouds of interstellar

The poet who saw the light

How one man's intuition explained Olbers' paradox almost a century before science got there

In February 1848, the American author and poet Edgar Allan Poe delivered a lecture on the nature of the Universe to an audience of around 60 people at the New York Society Library. He published it later that year as *Eureka: A Prose Poem*, a book he regarded as his masterpiece, but which left contemporary readers baffled.

Buried inside the speculative cosmological essay is the answer to Olbers' paradox, discovered without a telescope or mathematics. Poe reasoned that if the stars really did go on endlessly, the background of the sky would be one unbroken sheet of light. Since it is not, his explanation



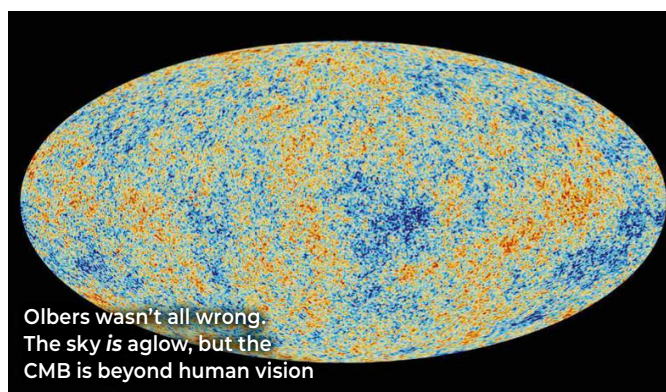
Poet Edgar Allan Poe beat Big Bang theorists to the punch

was that "the distance of the invisible background is so immense that no ray from it has yet been able to reach us".

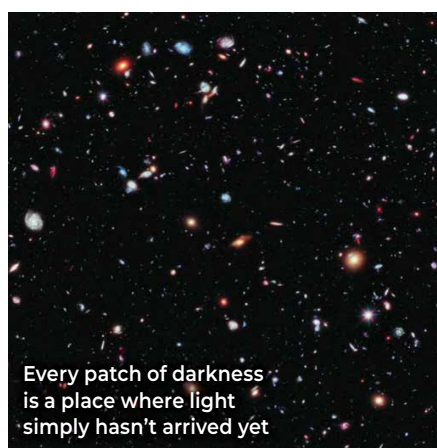
That insight contains the essence of the solution accepted today. Light takes a finite time to travel, and the Universe has not been going long enough for all of it to arrive. Poe had absolutely no evidence, but he unravelled the idea through a mix of intuition, theology and metaphysics, while modern cosmology took almost a century to catch up. Edward Harrison, the British astronomer who later traced the history of Olbers' paradox, credited the poet with getting there first.



In theory, stars should be everywhere we look, like trees in a dense forest



Olbers wasn't all wrong. The sky *is* aglow, but the CMB is beyond human vision



Every patch of darkness is a place where light simply hasn't arrived yet

dust were absorbing starlight before it reached us. It is a sensible thought, especially in the 1800s, when the prevailing model was of an infinite Universe. But it fails. Dust that absorbs starlight warms up, so since warm dust glows, the Universe would end up shining just as brightly as the stars it was supposed to be hiding.

Today we know the main reason for Olbers' error is that the Universe isn't infinite; most evidence points to it beginning 13.8 billion years ago. Since light travels at a finite speed, this means we can only see objects whose light has had time to reach us. If you look far enough in any direction, you will 'run out' of Universe – not because it stops, but because you have run out of time for light to make the journey to your eyes. The stars that would fill the gaps are either too distant for their light to have arrived, or had not even formed when the light we're receiving was created. Every patch of dark sky is, therefore, a region that starlight has not yet travelled across.

The expansion of the Universe contributes to this effect as well. As space stretches, the light that travels through it is stretched too, and the most distant sources are shifted out of the visible spectrum that we can see. However, calculations show the effect of expansion

is secondary compared to the fact that the Universe has a finite age.

But there's a twist. Point a microwave receiver at any empty patch of sky and you find a uniform glow arriving from every direction at once. This is the cosmic microwave background (CMB), the afterglow of the Big Bang, released when the Universe was around 380,000 years old and now cooled to 2.7° above absolute zero. In some sense, the blazing sky of Olbers' paradox is real. It is there in every direction, exactly as the argument expected. Expansion has simply stretched its wavelength so far past the reach of the human eye that it is no longer visible. 🌌



Andrea Henderson de la Fuente
(@astronomywith andrea on Instagram) is the author of *The Frontier of Astronomy*

Practical astronomy know-how for every level of expertise

SKILLS FOR STARGAZERS

Unlock your smart scope's equatorial mode

Switch to EQ tracking for longer exposures and cleaner deep-sky images



movement of the stars. It does this by aligning with the celestial pole which, for observers in the Northern Hemisphere, is where Polaris lies. This allows you to take longer exposures, resulting in an image without field-rotation artefacts. Even just increasing the exposures to 30 seconds rather than 15 will also reduce the noise.

Luckily, many smart telescopes can now track in EQ mode, so let's look at how yours can do it.

Point at the pole

Your smart telescope's tracking axis must first be aligned with the celestial pole. This is achieved by mounting it on a level tripod with a head that tilts backwards to point at it. The exact tilt depends on your latitude: for example, if you are located in the Northern Hemisphere at 52° north, the north celestial pole is 52° above the northern horizon; in the Southern Hemisphere at 35° south, the south celestial pole is 35° above the southern horizon.

Some tripods have divisions marked on them which make it easier to get the tilt correct, but you can also use a protractor to measure it. Once the tilt is correct, a compass will help you to point the telescope in the correct direction. You don't need to be absolutely spot on, because your smart scope's app will check the positioning and walk you through how to improve the alignment; the Seestar app even shows your position in real time, which makes this step easier. Our step-by-step guide shows how to do this.

Once you have the alignment correct, you can shoot longer sub-exposures and get much better deep-sky images, free of artefacts. EQ mode takes a little bit longer to set up, but it really unlocks the potential of your smart scope.

Smart scopes are easy to get imaging straight out of the box, with no prior experience of astrophotography or complicated mount set-ups required. But they do have their limitations.

In their basic mode, they track on an altitude-azimuth (altaz) grid system. That has its centre at the zenith (the point directly above you) and the grid divides the sky into segments. When following altaz grid lines, the smart telescope moves left to right and up and down. However, because Earth rotates on a tilted axis, this type of tracking does not perfectly follow the movement of the stars across the sky.

To compensate, smart scopes tend to limit their captures to short exposures of around 15 seconds. This isn't an issue for solar or lunar imaging, but when stacking deep-sky photos, each frame needs to be slightly rotated to align the stars. This 'field rotation' leads to stacking artefacts around the edges of the final image that have to be cropped out. The rotating edges only get worse the longer you're imaging, eventually impacting your image quality.

In contrast, when a telescope is set up to track in equatorial (EQ) mode, it can accurately follow the

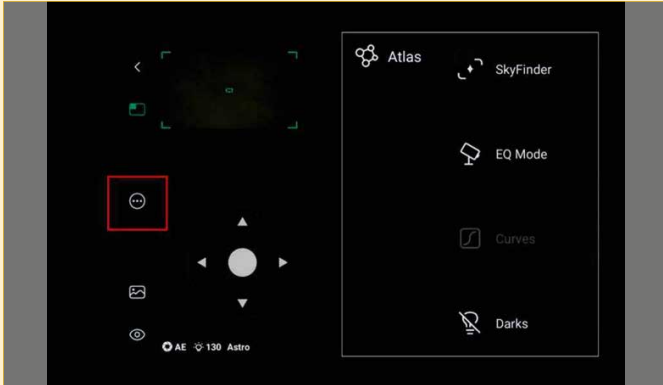


Mary McIntyre is an outreach astronomer and teacher of astrophotography

What you'll need

- ▶ Smart telescope and corresponding app
- ▶ Robust tripod with tiltable head – a specific smart telescope tripod, a telescope tripod with equatorial wedge or a sturdy camera tripod
- ▶ Protractor to measure the tilt, if your tripod doesn't have latitude markings
- ▶ Compass to point the telescope towards north or south (depending on your latitude)

Step by step



Step 1

Power up your smart scope and connect it to its app on your phone or tablet. In the app set-up menu, select EQ mode. If you are running the scope from mains power, check that you have enough cable clearance for the telescope alignment process.



Step 2

Attach the smart scope to the level tripod. Always follow the guidance in your app to ensure the telescope axis is oriented the correct way. Dwarf and Seestar scopes mount differently; incorrect orientation will cause the polar alignment to fail.



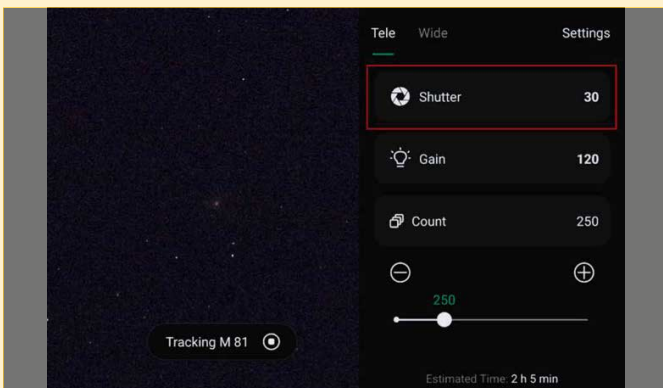
Step 3

Tilt the tripod head or wedge back the appropriate number of degrees for your latitude, using the tripod markers or a protractor. Ours was tilted by 52°. Ensure one tripod leg is located beneath the tilted scope to support the weight securely.



Step 4

Using the compass, point the telescope towards the celestial pole (Polaris in the Northern Hemisphere). Instruct the app to check the alignment. Follow the app guidance to make any necessary adjustments until you reach precise alignment.



Step 5

Select your deep-sky object and choose some longer sub-exposure times. It was mid-summer, so we chose M81 and 30 seconds, then set it to capture 250 images. You could go for even longer exposures during the winter months.



Step 6

Once the imaging run is complete, process the stacked photo using the app's processing tools, or download and process it with external software. Your image should now show less noise and fewer field-rotation artefacts around the edges. 🌌

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Record a planetary U-turn

Build an eye-catching sequence showing Mars and Jupiter reverse course

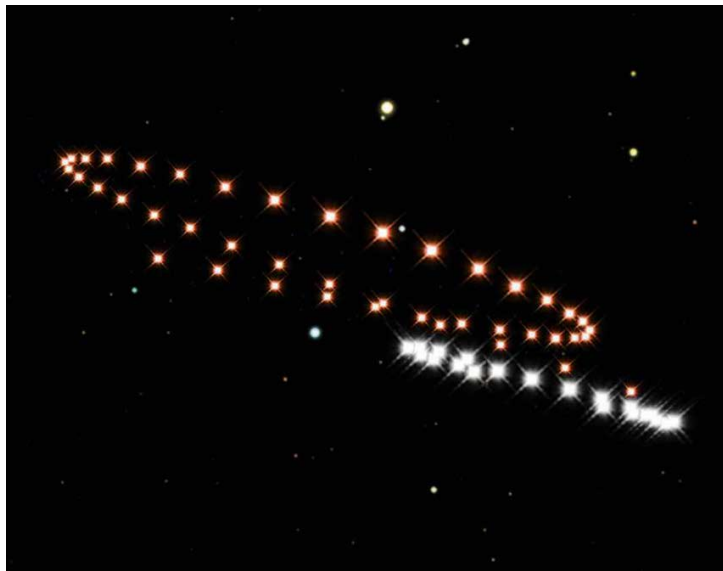
Things are hotting up in the morning sky as Mars and Jupiter

now appear close enough to reveal something interesting – namely, that Mars is a fast mover. Jupiter is more of a plodder, moving once around the entire zodiacal band every 11 years. Mars is much closer to us, and when it approaches opposition it really starts to speed through the constellations. The Red Planet is next at opposition in mid-February 2027, so now is a great time to start recording its motion. This month, we'll show you how to build a library of images that can later be compiled into a sequence revealing that movement.

Snap the scene

There are various ways you can do this. Jupiter is bright enough to record fairly easily on modern smartphones. Nearby Mars, as well as the star Regulus, shouldn't be too much of a problem either. Give it a try. If you can catch both planets and some stars, then you're all set. Just keep repeating the process, making sure to include the same background stars, and you'll have enough images to compile a movement sequence.

If you're using a more sophisticated camera, such as a DSLR or a MILC, you should easily be able to capture the planets and stars, but you'll need to choose a lens that provides suitable coverage. In theory, any that can cover both planets and some background stars should do. If Mars later moves out of the original scene framing, you should still be able to combine the images, as long as you can match stars between frames. Lens quality is important – one



▲ Your finished montage will showcase Mars and Jupiter's retrograde loops, when the planets appear to stop then backtrack across the sky



Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

that delivers a good flat field to the edge of the frame will make the job far easier. Unfortunately, many don't, so it pays to plan ahead and adjust your lens selection accordingly.

So what should you plan ahead for? Mars is currently heading west to east, exhibiting what's known as prograde motion. As it approaches opposition, however, it will do something odd. It will slow its eastward motion and then, on 10 January 2027, it will come to a halt and begin heading back towards

Jupiter in an east-west or retrograde direction. What's more, Jupiter – which is also heading for opposition next February – will do the same thing, just not in such a dramatic way. Eventually, both will slow down and reverse direction again to resume their prograde motion. The pattern they trace out in the night sky is known as a retrograde loop.

Now is the perfect time to practise and try to perfect your capture technique. This will allow you to hone your skills, as well as grabbing some useful early positional shots of Mars and Jupiter against the stars of Leo. This area of sky remains visible in darkness until the middle of May, so there should be plenty of opportunities to capture a decent number of frames to reveal both planets undergoing their retrograde loops.

Equipment: Widefield camera and a tripod or tracking mount

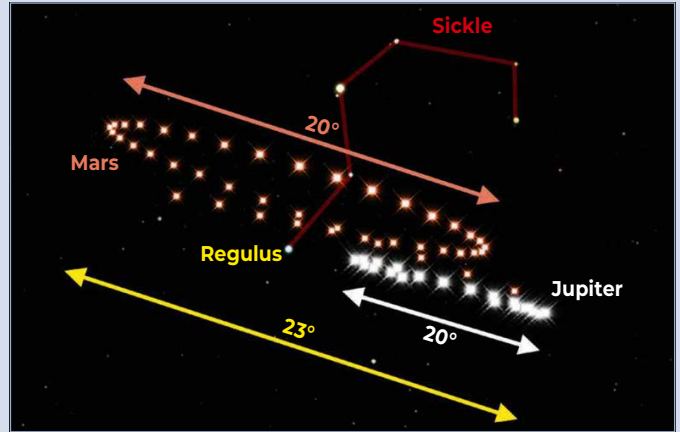
✉ Send your images to:
gallery@skynetmagazine.com

Step by step



Step 1

While DSLRs and MILCs are ideal, a smartphone can be used provided it records the planets and background stars. Use a tripod mount. As this project spans many weeks, create a master starfield shot for the final composition. Processing this may create a mismatch in the planets' appearance, so clone them out if needed.



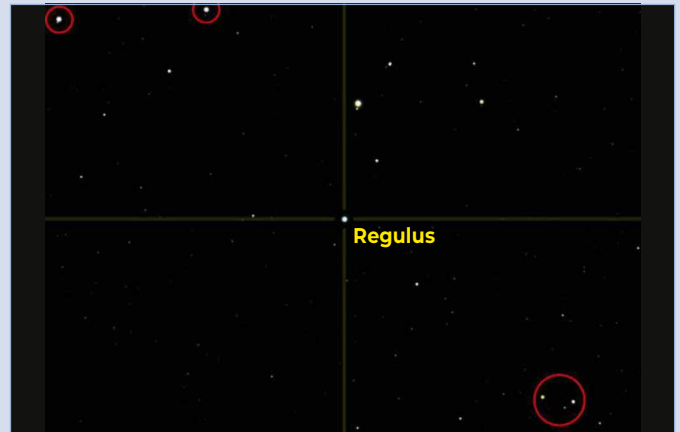
Step 2

The planets' motions come alive when a number of star-aligned images are composed together. Mars's retrograde loop is 20° wide and 2.5° high. Jupiter's is much flatter and harder to reveal. Including Jupiter with Mars requires a field at least 25° (preferably 30°) across to record both loops comfortably.



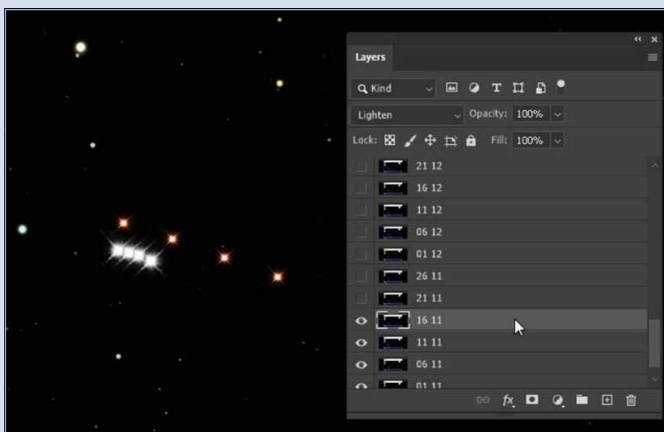
Step 3

While this is a widefield project, bear in mind that Jupiter's retrograde loop is only 10° wide. Go too wide and it'll become lost. A dedicated 'Jupiter loop' shoot is a better option. Either way, it's essential to record several background stars; they're the anchors needed to align images from different nights.



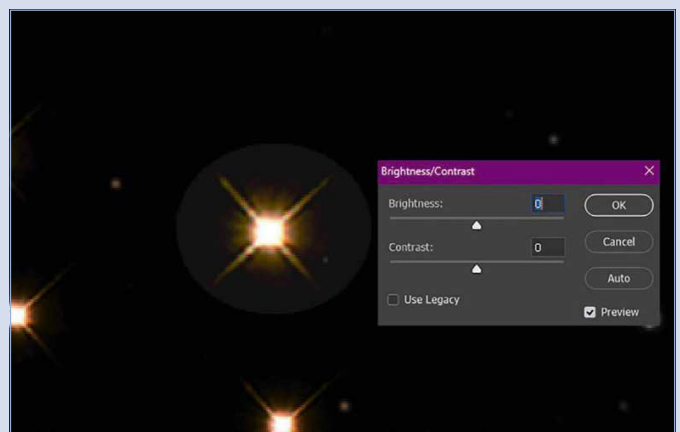
Step 4

Position Regulus (Alpha Leonis) at the centre of the frame. It helps to include another star or pattern near a frame corner. For added drama, fit a cardboard collar in front of your lens with crossed cotton threads stuck on it, crossing the field of view. This will create diffraction spikes on the bright planets.



Step 5

Take images on clear nights from now until May 2027. These are for the planets' positions, so Moon interference isn't a concern. Label each image. Open the master starfield shot in a layer-based editor. Add the sequence images as hidden layers. Make each upper layer visible in turn as you work on it.



Step 6

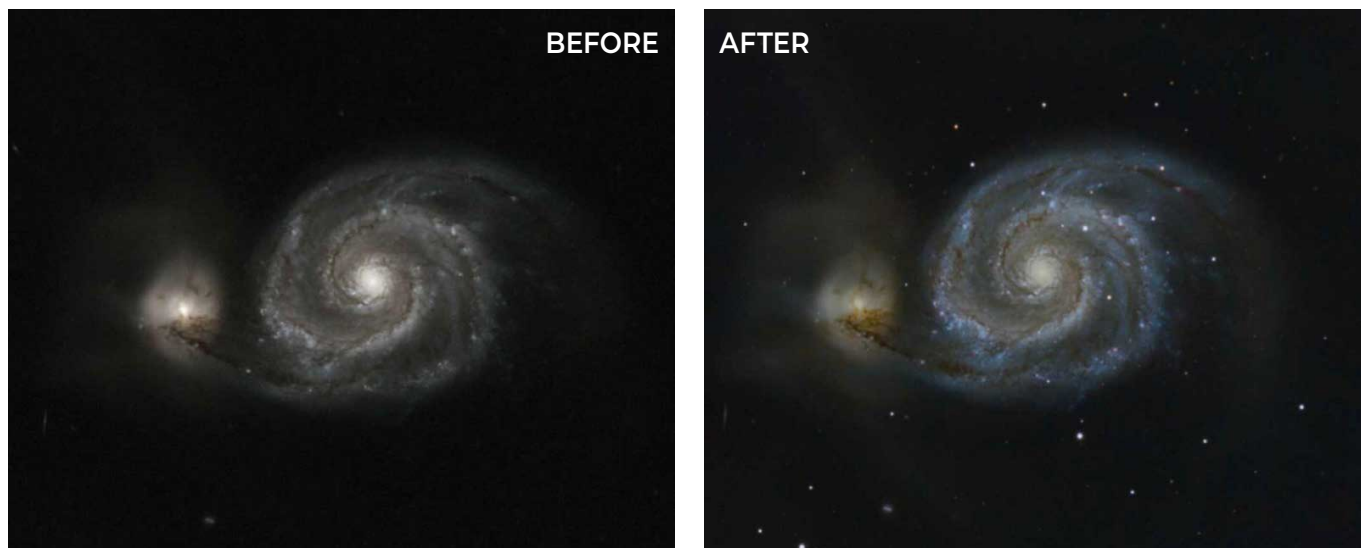
Align each sequence image layer to the master starfield. Create a feathered selection around each planet, invert it and delete the surrounding stars. Set the blend mode to Lighten; darken the surroundings slightly if any edges show. Don't worry about weather-related gaps. They're normal in long-term composites. 🌌

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

How to process stars separately

Remove, refine and recombine stars using two powerful free tools



▲ The Whirlpool Galaxy (M51) before and after separate processing of the galaxy and star field. Working on a starless image (left) gives you greater control over your target's colour, noise and faint detail before the stars are recombined into the final image (right)

While there are many comprehensive astrophoto-processing programs to buy, there are also plenty of wonderful free options. StarNet++ is a simple tool that removes stars from your images. It can be used as a standalone program or as a plug-in for popular software such as PixInsight and Siril.

Why remove the stars? Aside from an aesthetic choice, it can be a useful processing step, allowing you to stretch an image to reveal more detail without overprocessing the stars. StarNet++ can also remove stars from narrowband data, letting you combine channels without introducing oddly coloured stars, or add narrowband data to broadband images while preserving natural star colours.

Here we'll walk you through removing stars from an image in the initial stage

of processing using StarNet++, then recombining them using the free cross-platform program GIMP.

Begin by opening your image in your astrophotography image-editing program of choice. Apply a basic histogram stretch until you're happy with the look of your stars. You may also wish to complete background extraction, SCNR (green noise reduction), deconvolution, colour calibration and cropping before stretching. Once you have stars that you don't wish to stretch further, save the image as a 16-bit unsigned integer TIFF image. This is vital, because StarNet++ can struggle to open other formats.

Open your image in StarNet++ (see Screenshot 1). In the simple dialogue box, use Browse in the Input File box to select your image. In the Output File box, rename the starless image you will create to something more descriptive, to avoid

confusion or accidentally overwriting previous versions.

Strip out the stars

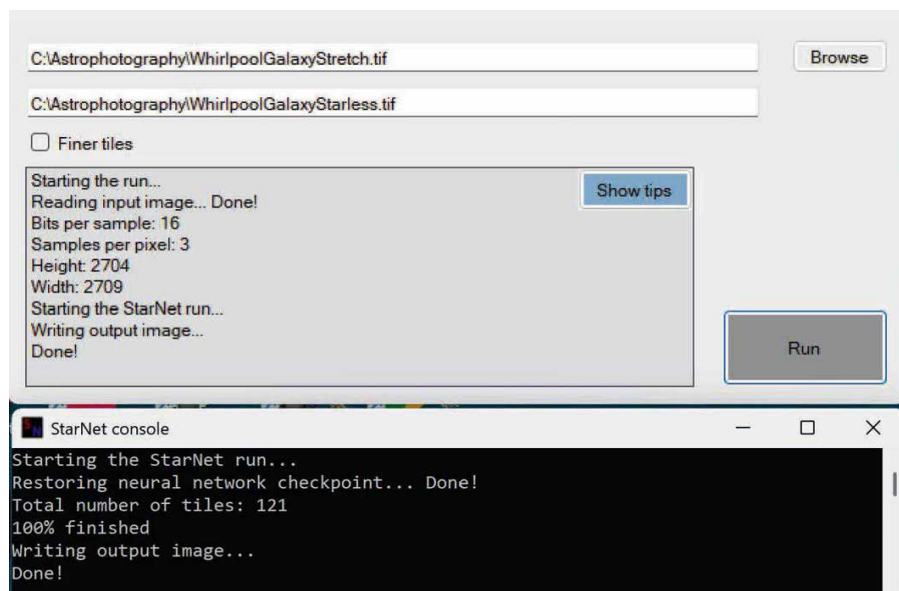
There is also an option to use smaller tiles, allowing StarNet++ to analyse smaller sections of the image and potentially help with blending large, bright stars and haloes. However, start with the default settings, which usually work well. After that, all you have to do is click 'Run' and StarNet++ will start creating your starless version. Its progress will be displayed as a percentage in the dialogue box until you see the message 'Done!'.

Once StarNet++ has created your starless image, you can process it as desired before preparing the stars for recombination. To do this, open both your starless and original with-stars images in GIMP (see Screenshot 2). Select the starless image and click Edit > Copy. Select

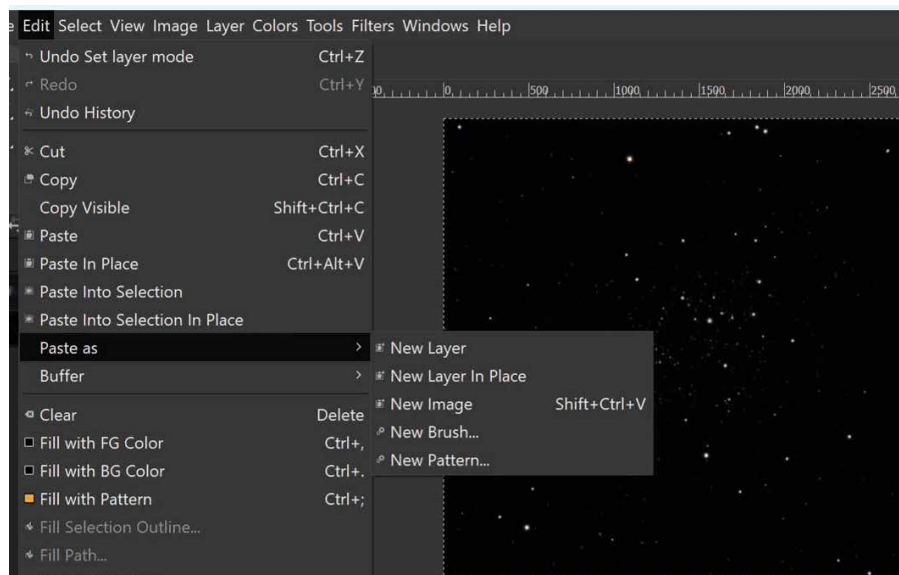


3 QUICK TIPS

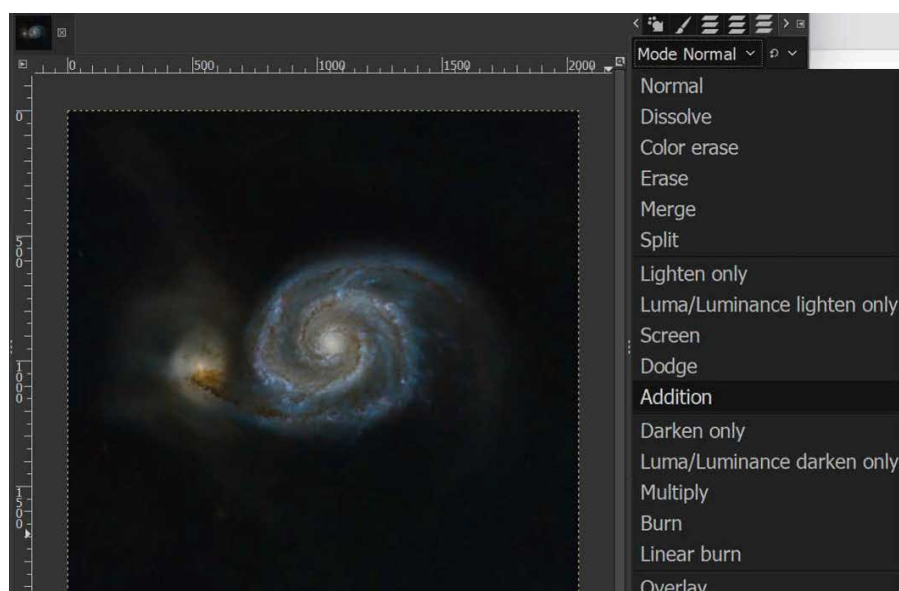
1. Reduce stars in GIMP using Value Propagate > More Black. Be careful: too much reduction can cause issues when the stars are added back in.
2. In Addition mode, adjust the star layer's opacity using the slider on the right-hand side.
3. Every layer mode in GIMP has a default and legacy option. Try both to see which works best for your image.



▲ Screenshot 1: load your image into StarNet++, choose a helpful filename for the new starless version and click 'Run'. StarNet++ will automatically remove the stars



▲ Screenshot 2: in GIMP, open your original and the starless version. Paste the starless version into the original as a new layer. Use Subtract mode to create a stars-only image



▲ Screenshot 3: carefully process the stars-only image, combine it with the starless version using Addition mode and voilà: a finely balanced astrophoto with the best of both

the original with stars, then click Edit > Paste As > Paste as New Layer to add the starless image as a layer from which you'll effectively subtract the stars.

On the right-hand side are your layer modes. Scroll down and select Subtract. GIMP will now show an image of your stars only, without the background. Click Image > Flatten Image to turn the stars-only result into a single layer for the next steps.

Fine-tune the stars

The 'stars only' layer can now be processed to add or decrease saturation, denoise or even reduce stars. However, once you merge the stars back into the image, take care not to introduce unwanted artefacts. This can happen due to overprocessing, so it's always a good idea to scale back, give everything a good check and go back a step if you find that the transition between stars and background is no longer smooth.

Once you have processed your stars-only and starless images to your liking, it's time to recombine them. To select the stars image, click Edit > Copy in the header menu. Select the starless image and click Edit > Paste As > Paste as New Layer. You'll again need to change your layer mode, so go back to the box on the right-hand side and this time select Addition (see Screenshot 3). GIMP will now combine these two layers into one. As a final step, it is important to click Image > Flatten Image before saving your final, finished image in your desired format. 📁

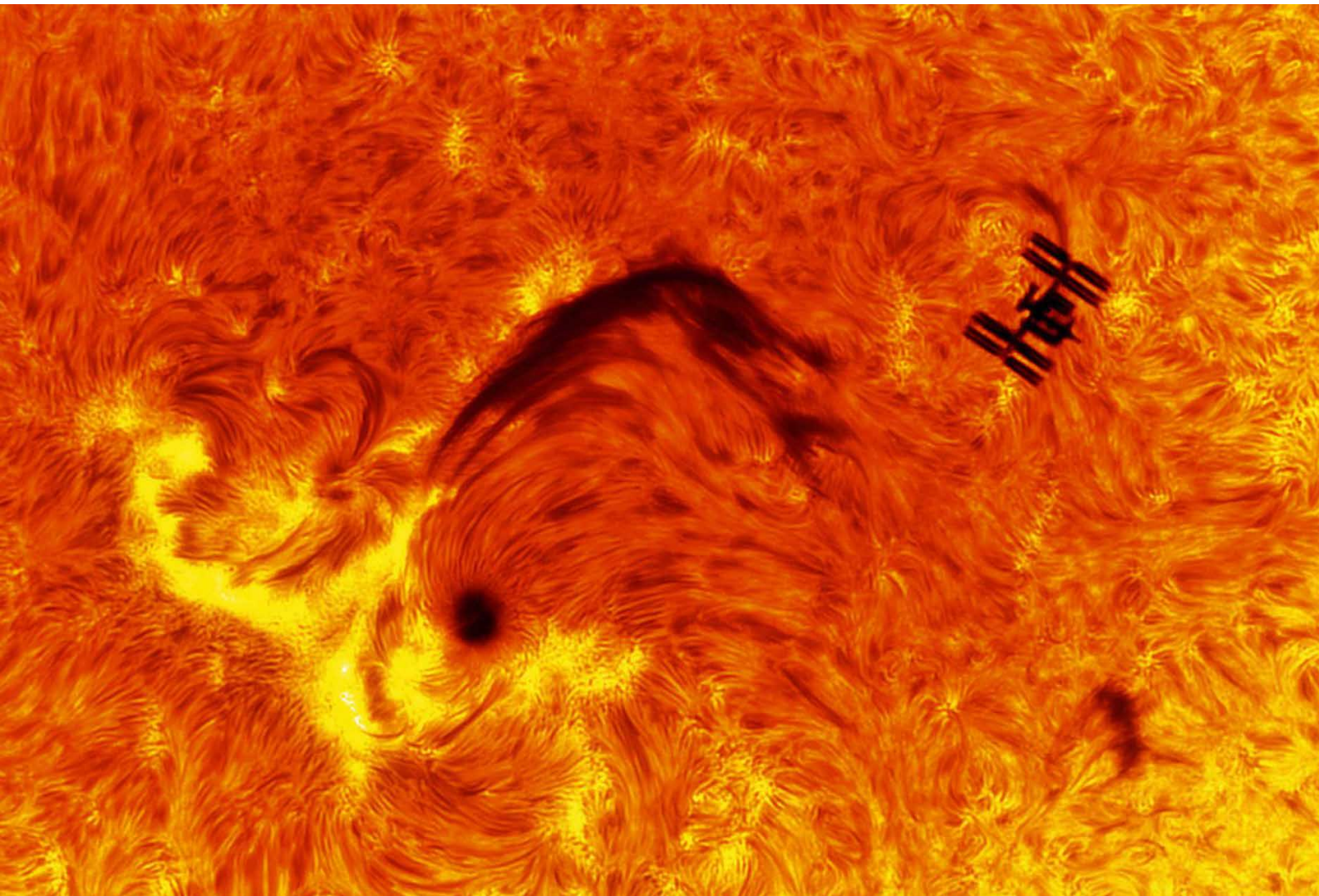


Ivana Peranic is a cellist by day and astrophotographer by night, based in Brighton, UK

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△ ISS solar transit

Tianyao Yang, Lianyungang, Jiangsu, China, 1 August 2026



Tianyao says: "Planning the alignment for this shot of the International Space Station crossing active regions AR4498 and AR4500 was

a tense waiting game. With only a 0.58-second window, I was holding my breath, but seeing the sharp ISS silhouette pop up on my screen was immensely satisfying."

Equipment: Player One Apollo-M Mini camera, Sky-Watcher Heliostar 100Ha solar telescope, iOptron HAE18C mount

Exposure: 0.0003"

Software: AutoStakkert!, ImPPG, Photoshop

Tianyao's top tips: "Catching the ISS transiting a specific active region requires double calculations. I fetch real-time

hydrogen-alpha solar imagery from the Global Oscillation Network Group (GONG) and rotate it to align with celestial north for the exact transit time. Combining this with orbital data for the space station lets me locate the ground path where the ISS slices through the sunspots. I then use a global-shutter sensor and high-speed capture to freeze that moment without distortion."

NGC 4725 ▷

Andrea Bavaro,
Astronomical Observatory
of the Autonomous Region
of the Aosta Valley, Italy,
19 March 2026



Andrea says:

"I love searching for lesser-known targets and this galaxy's

distinctive arm fascinated me. After a clear night with excellent seeing, patient processing rewarded me."

Equipment: Moravian G2-4000 Mono camera, GSO 10-inch f/8 Ritchey-Chrétien, Gemini G53F mount

Exposure: L 23x 600", RGB 15x 300"

Software: PixInsight, Photopea



△ Milky Way

Chandresh Kedhambadi, Great Sand Hills,
Saskatchewan, Canada, 2 July 2021



Chandresh says: "Capturing this shot of the Milky Way rising was a challenge. I had to hike around the scene in order not to disturb the sand patterns by introducing unwanted footprints!"

Equipment: Canon EOS 5D Mark IV DSLR camera, Sigma 20mm lens, Gitzo GT1545 tripod

Exposure: foreground ISO 1000 f/2.8, 5"; sky ISO 5000 f/2.0, 16"

Software: Lightroom, Photoshop

▽ Solar eclipse

Hayley Smith, Milton Keynes,
Buckinghamshire, UK, 12 August 2026

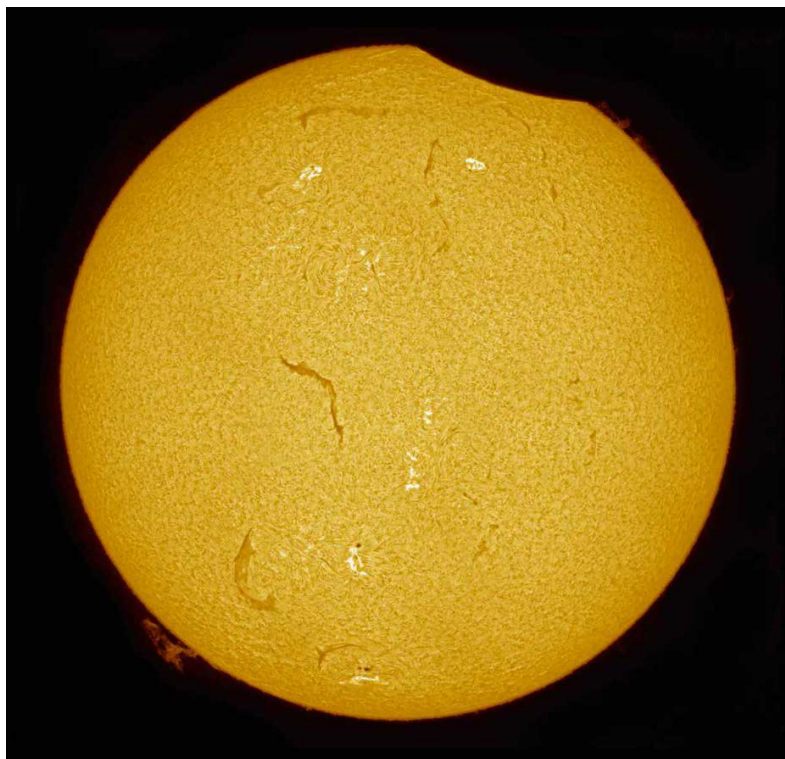


Hayley says: "I love photographing the Sun in hydrogen-alpha: it's so dynamic and alive. A solar eclipse adds excitement, revealing the remarkable mechanics of our Solar System."

Equipment: ZWO ASI174MM camera, Sky-Watcher Evostar 80ED refractor, Celestron AVX mount

Exposure: 22 panels, best of 1,000 video frames, stacked

Software: AutoStakkert!, ImPPG, Photoshop





◀ Perseid meteor shower

Jaymie Clifford, Cradley,
Herefordshire, UK, 12 August 2026



Jaymie says:

"I wanted a new challenge and a Perseids composite seemed perfect. The trickiest part was the framing."

Equipment: Altair Astro 269C camera, Samyang 8mm lens, Sky-Watcher HEQ5 Pro mount

Exposure: background 123x 120"; meteors 458x 15"; foreground 1x 300"

Software: PixInsight, Photoshop, GraXpert

Lunar eclipse ▶

Kimberly Sibbald, Seven Skies
Observatory, Alberta, Canada,
27 August 2026



Kimberly says:

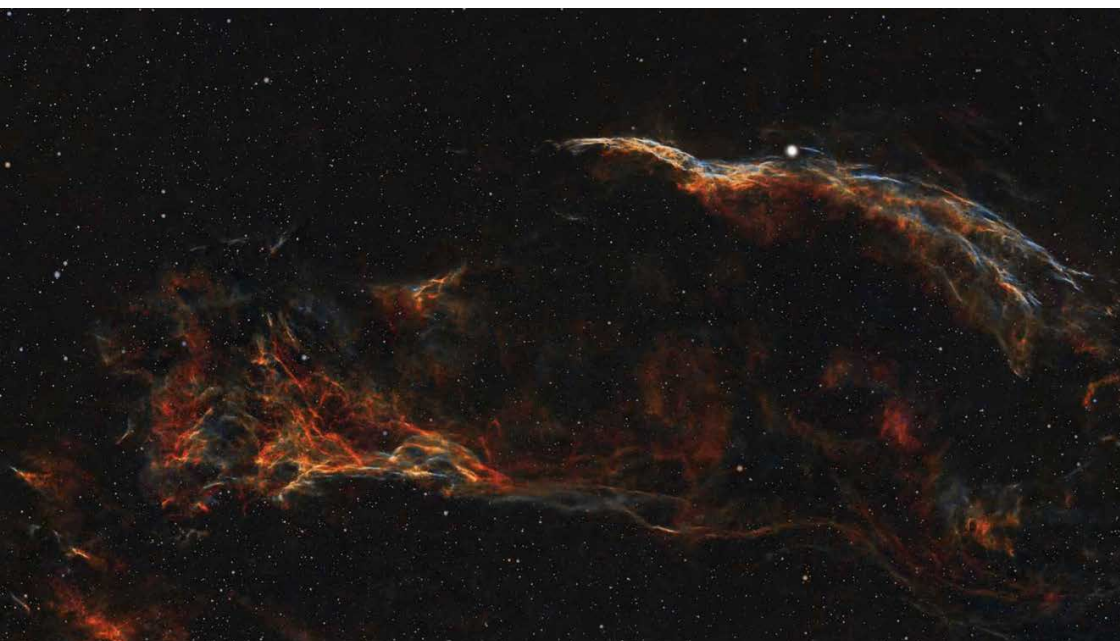
"My vision was to show the eclipse as the naked eye would see it."

Moisture after a thunderstorm, thin cloud and forest-fire smoke made this night unique: the atmosphere is the picture here."

Equipment: Canon EOS R DSLR camera, Canon 70–200mm lens, Gitzo Series 2 eXact tripod

Exposure: ISO 100–3200
f/3.2, 5x 2"

Software: Photoshop



◀ The Veil Nebula

Alana Smith, St Albans,
Hertfordshire, UK, 21 July 2026



Alana says:

"I only started astrophotography in February. A friend suggested

NGC 6960. Seeing the Witch's Broom and Pickering's Triangle appear was incredibly exciting!"

Equipment: ZWO ASI585MC Air camera, Sharpstar 61 EDPH III refractor, ZWO AM3N mount

Exposure: 60x 60"

Software: PixInsight

The Sadr region ▷

Patrick Cosgrove, Honeoye Falls, New York, USA,
11/12 and 22/23 July 2026



Patrick says:

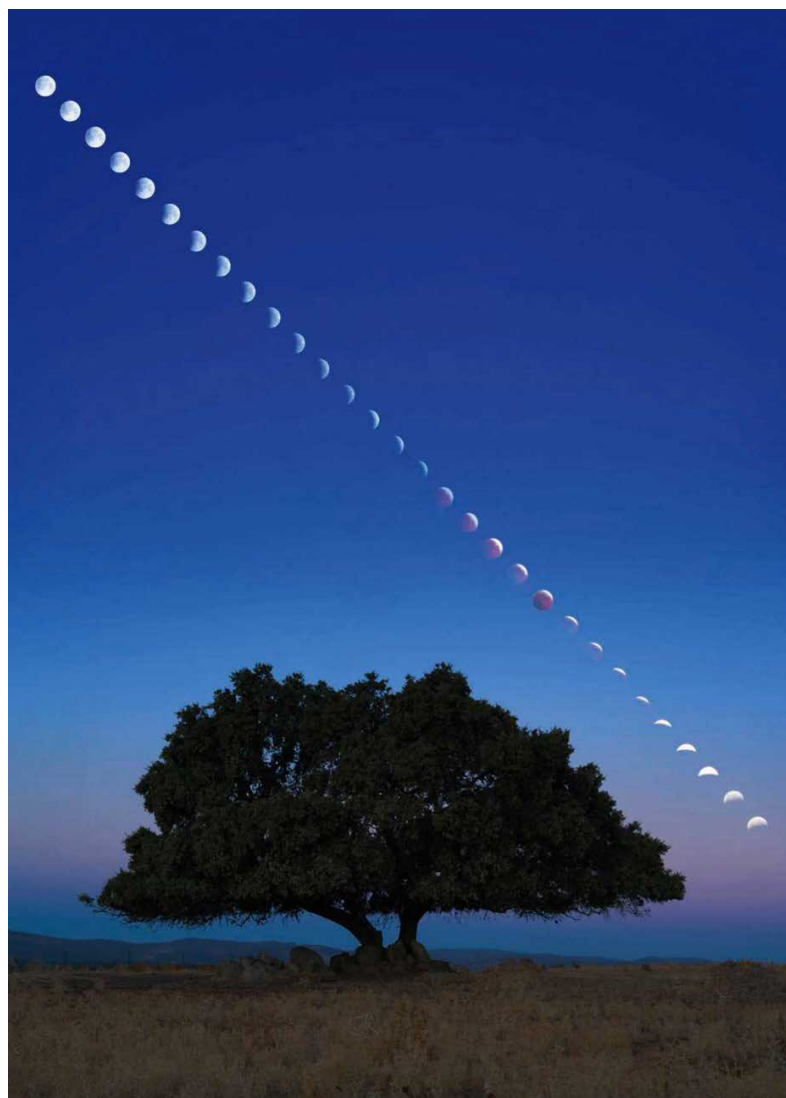
"Despite clouds, wildfire smoke and some lost data, the final

image reveals wonderful structure and depth."

Equipment: ZWO ASI2600MM Pro camera, Askar FRA400 refractor, ZWO AM5 mount

Exposure: RGB 37x 60", Ha 44x 300", OIII 41x 300", SII 46x 300"

Software: PixInsight, Photoshop



◁ Lunar eclipse stages

Miguel Gracia, Cáceres, Extremadura, Spain, 28 August 2026

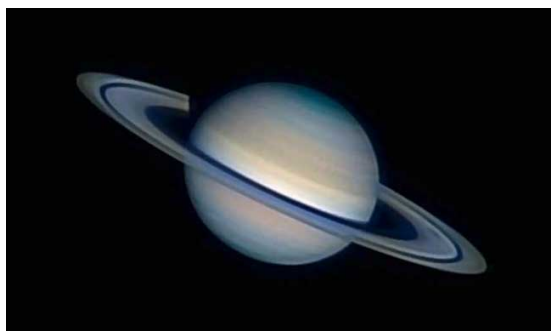


Miguel says: "The moment I saw this lone holly oak, I knew my eclipse sequence had to happen here."

Equipment: Sony A7 III camera, Sky-Watcher Evostar 72ED refractor, Sky-Watcher Star Adventurer mount

Exposure: ISO 200, 1/500" to ISO 640, 1/30"

Software: Photoshop



△ Saturn

Pietro De Gregorio, Massa Lubrense, Naples, Italy, 11 July 2026



Pietro says: "I've been imaging planets for many years, so Saturn is an integral part of my hobby. I'm very satisfied with this capture."

Equipment: ZWO ASI485MC camera, Celestron C11 XLT Schmidt-Cassegrain, Celestron CGEM mount

Exposure: 6x 2"

Software: AutoStakkert!

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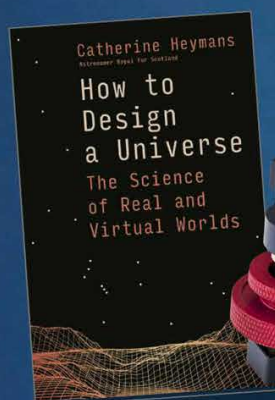
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86

"There's just something about it that looks and feels right." Find out why Sky-Watcher's revamped Evostar 100EDX hits the sweet spot



PLUS: books on how to build universes and space stations, a poetic take on comets, and our latest gear picks

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

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Our experts review the latest kit

FIRST LIGHT

Sky-Watcher Evostar 100EDX refractor

Thanks to a major makeover, this good-value refractor is now a knockout all-rounder

WORDS: TIM JARDINE

VITAL STATS

- **Price** £599
- **Optics** ED apochromatic doublet
- **Aperture** 100mm
- **Focal length** 700mm, f/7
- **Focuser** 2.8-inch dual-speed 11:1 Crayford
- **Extras** Carry case, tube rings, adaptors
- **Weight** 5.5kg
- **Supplier** Optical Vision Ltd
- **Email** info@opticalvision.co.uk
- **www.** opticalvision.co.uk

ALL PICTURES: @THESHED_PHOTOSTUDIO

Sky-Watcher's Evostar telescopes have a deserved reputation for quality, and the latest upgrades to the 100mm model aim to make it an even better dual-purpose telescope for both astrophotography and visual observation. We wanted to put that to the test.

When first lifting the Evostar 100EDX from its case, we could quickly tell that the term 'upgrade' doesn't really cover the improvements. This is essentially a whole new telescope, with redesigned optics, a new focuser and fancy new livery in Sky-Watcher's sparkly white with anodised green trim. Four-inch (100mm) refractors are often touted as the perfect balance between aperture and portability, and there is something about the Evostar 100EDX that just looks and feels 'right'. We couldn't wait to try it with an eyepiece and a camera.

Our review package contained the optical tube only, so we used our own star diagonal and eyepieces. We also received an optical field flattener for imaging use, available as an additional option. With the telescope nicely cooled, we set about star-testing it, initially using a Ronchi eyepiece. This returned excellent results, with no

sign of astigmatism and no untoward aberrations, reassuringly displaying straight line patterns on either side of focus. We popped in our highest-magnification eyepiece, along with a 2x Barlow lens, which produced a magnification of 311x, just over the theoretical practical maximum for a 100mm scope.

Addicted to the views

Our primary target was the famous Double Double in Lyra, a pair of very close double stars that especially reward high-end optics. We were not disappointed. All four stars were perfectly resolved, round and distinct, and exactly what we hoped for.

Satisfied with this excellent view, we swapped to our 13mm 100° eyepiece for a very comfortable 54x magnification, touring colourful double stars and the lunar surface. We looked for any signs of chromatic aberration at the eyepiece and found none. After a while, we realised that we'd switched from reviewing optics to getting engrossed in an observing session, because we were enjoying the visual performance of the Evostar 100EDX so thoroughly.

With some reluctance, we removed the observing accessories and attached our imaging gear. The flattener screws directly to the rear of the focuser; ►

Keeping colour under control



The Evostar 100EDX features an f/7 apochromatic doublet objective lens, including a Japanese Ohara FPL53 glass lens to keep chromatic aberration to a minimum. Chromatic aberration is the unwanted colour fringing you can get, particularly when observing bright targets. It can also spoil colour astro images, causing stars to display as different sizes in each colour channel, giving a fuzzy, out-of-focus appearance.

To check Sky-Watcher's claim that the Evostar 100EDX's lens "virtually eliminates chromatic aberration", we

targeted a bright star with our mono CCD camera and, using parfocal filters, focused using a red filter. We then switched to blue and green filters and compared the star size and the Bahtinov mask pattern. There was no discernible difference between the red and blue results, and only the slightest deviation through the green filter, confirming Sky-Watcher's claim. Switching to our DSLR, we could split the star images into separate channels and then compare star size. Here too we found our results supported the claim.



Baffles/lens coatings

A large extending dew shield, internal black tube baffles and Sky-Watcher's premium metallic high-transmission coatings on the lens surfaces work together to produce excellent high-contrast images at both the eyepiece and the camera, eliminating stray light and unwanted internal reflections.



Tube rings and handle

The Evostar comes with dedicated tube rings attached to a Vixen-style dovetail bar. It also includes a very useful carrying handle that doubles as an accessory rail and incorporates a standard 1/4-inch-20 camera-screw thread. A shoe fixed on top of the tube accepts all standard Sky-Watcher finderscopes.

Focuser

The focuser is a backlash-free Crayford design unit with dual-speed controls. Dual locking screws hold it firmly without tilting the tube, and the action is smooth and accurate. The 2.8-inch drawtube is indexed with an accurate scale for quick, repeatable focusing. It incorporates a 360° rotating ring at the rear.

Compact and lightweight

The proportions, length and central balance of the Evostar 100EDX make it extremely manageable and easy to fit to a mount. The optical tube weighs just 5.5kg. With the dew shield fully extended, it's only 675mm long, making for comfortable viewing positions, no matter where in the sky your target may be.

FIRST LIGHT

KIT TO ADD

1. Sky-Watcher 2-inch deluxe star diagonal
2. Sky-Watcher field flattener for Evostar 100EDX
3. Sky-Watcher 9x50 DX finderscope

► a provided adaptor lets you transition from the flattener to a 48mm male thread, intended for a DSLR camera T-ring or astrophotography camera. We tried both, each with a large full-frame sensor. This gave an imaging area larger than the 40mm circle the flattener is designed for, so stars in the corners of our pictures looked stretched. The star distortion was equal in each corner,

demonstrating that there is no slop (unhelpful movement) in the focuser, or optical issues with tilt.

A flat-frame exposure confirmed this, as the slight vignetting in the corners of our full-frame images was nicely symmetrical. To be clear, with typical DSLR or CMOS sensors, the stretched stars and the vignetting should not be noticeable, but our equipment exceeded the limits of the optical design.

Deep-sky photo tests

With the large field of view on offer from the 700mm (f/7) optics, a natural target was the Andromeda Galaxy, M31, and its companions M32 and M110. We were limited by the short summer nights during the test period, so chose some narrowband targets too, but the Evostar 100EDX really demonstrated its potential for imaging, with the new focuser smoothly taking us to pin-sharp stars.

Using a Bahtinov mask, we noted that tiny movements were enough to shift the focal point, so the silky accuracy of the fine-focus control was appreciated. A rotator built into the rear green ring on the focus tube makes framing the target easy. A minor drawback was that tightening the rotator thumbscrew nudges the camera a couple of degrees clockwise, but overall we were very impressed with the images our cameras collected.

The re-envisaged Sky-Watcher 100EDX successfully delivers on its dual-purpose promise. A very capable observing and imaging telescope, it should be a definite contender for anyone looking for an affordable all-rounder. 🌌

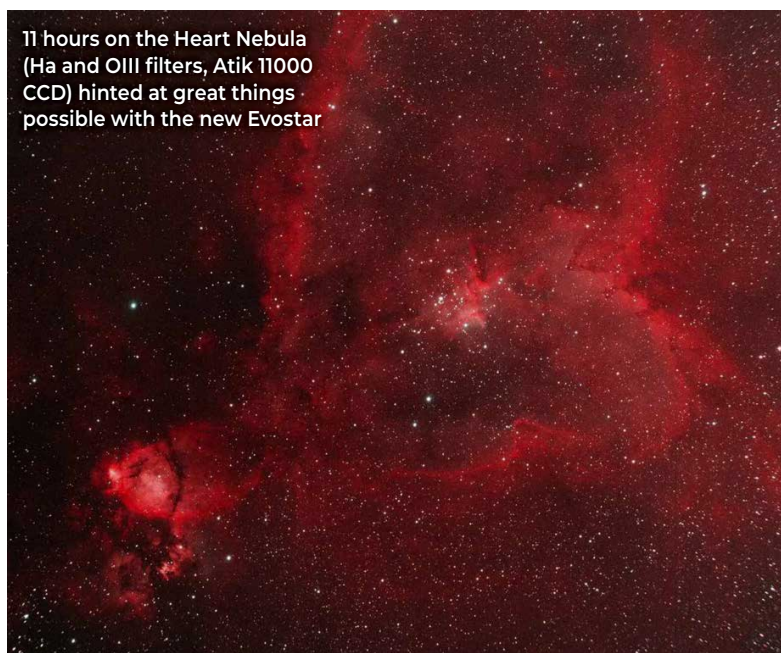


Carry case

A foam-padded, lockable aluminium case provides a safe, portable storage option with enough space for extra accessories, including the optional field flattener. The accessories include a 2-inch clamp, a step-down 1.25-inch clamp and a screw-on threaded adaptor for the flattener.



Eventually we tore ourselves away from observing to capture this sharp M31. Canon 6D, 3 hours of 60-second exposures



11 hours on the Heart Nebula (Ha and OIII filters, Atik 11000 CCD) hinted at great things possible with the new Evostar

VERDICT

Build & design	★★★★★
Ease of use	★★★★★
Features	★★★★★
Imaging quality	★★★★★
Optics	★★★★★
OVERALL	★★★★★

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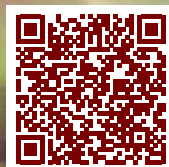


Image: P. Jennings

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Our experts review the latest kit

FIRST LIGHT

Pentax Jupiter 10x50 binoculars

Affordable but with a premium feel, these offer an enjoyable first step into astronomy

WORDS: STEVE TONKIN

VITAL STATS

- **Price** £67
- **Optics**
Multi-coated
- **Aperture** 50mm
- **Magnification**
10x
- **Prisms**
Porro, BaK7
- **Angular field of view** 6.5°
- **Focusing**
Centre focus
- **Eye relief** 13mm
- **Interpupillary distance**
58–71mm
- **Weight** 870g
- **Supplier** First Light Optics
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Sometimes with new binoculars, you get a sensation of “ooh, these feel nice”. That’s what happened when we first unpacked Pentax’s Jupiter 10x50 binoculars, and we weren’t disappointed as we proceeded to test them for astronomy use.

That good feeling is due to a purpose-designed body construction that gives an immediate sense of robustness. These are not your run-of-the-mill generic budget binoculars: the body is completely covered with a slightly textured rubber armour, which is sculpted around the prism housings to enable you to hold them securely with one or two hands. It is thickest on the most vulnerable edges. All moving parts felt suitably tight but smooth, with no discernible resistance.

Putting the optics through their paces, we generally liked what we saw. The central 50 per cent of the 6.5° field of view is sharp, but there is some drop-off in image crispness outside this. This is due to field curvature (different regions of the image focusing at slightly different distances), which affects all but the best binoculars. There is also some lateral chromatic aberration, green-yellow or blue-purple fringing on high-contrast objects, such as Venus or the lunar terminator and limb. This is not

particularly obtrusive in the focus sweet spot and is something you’ll find in all achromatic binoculars that don’t use expensive ED glass.

We also noticed some pincushion distortion, where straight lines near the periphery bow in slightly towards the centre. This is deliberately introduced because it prevents a potentially nauseating phenomenon called the ‘rolling ball effect’ when you are panning around a starry sky.

How they’re looking

Before getting out under the stars, we conducted some cursory optical bench tests, which revealed that the effective aperture is internally stopped down to 44mm. The stopping down is intended to sharpen the image at the expense of some loss of brightness. It also showed small grey segments in the exit pupils, a telltale sign that the prism glass is low index. Low-index prism glass gets a bad rap, but it is entirely appropriate in some applications, this being one of them.

The interiors of the objective tubes are ribbed, and there are two baffles between the objective lens and the prism housing, intended to reduce the effect of stray light. The objective lenses themselves are recessed a little more than 10mm, enough to protect ►

A comfortable pleasure to use

If your binoculars are a pleasure to use, you’re more likely to use them. Pentax has hit the Goldilocks zone with these: they feel just right. Firstly, they are quite light for 10x50s. The textured rubber armour makes them comfortable to use, whether that’s holding them by the barrels for horizontal viewing, or with your thumbs resting on your cheekbones for high-elevation astronomical targets.

The rubberised centre focus wheel and right eyepiece dioptre are chunky enough to use with thick winter gloves.

The focus mechanism is smooth, without any discernible backlash, so precise focusing is easy. The right eyepiece dioptre focus ring is also smooth and has just the right amount of resistance to prevent it being inadvertently altered after you’ve set it.

The central hinge is stiffer than both the focus adjustments, so you are unlikely to accidentally change the interpupillary distance while you’re adjusting focus but, if you do, it’s smooth enough to make it easy to adjust back.



SCALE



Neck strap

Binoculars spend a lot of time hanging around your neck, so a comfortable neck strap is a must. We found the 19mm-wide webbing to be perfectly adequate to the task, even on a bare neck. You can adjust the length to make it suitable for thick winter clothing.



Multicoated optics

Multicoatings are anti-reflective layers that improve the transmission of light through an optical surface. Both the front of the objective lens and the rear of the eye lens have these coatings, which help to transmit most of the gathered light, ensuring the images you see are suitably bright.



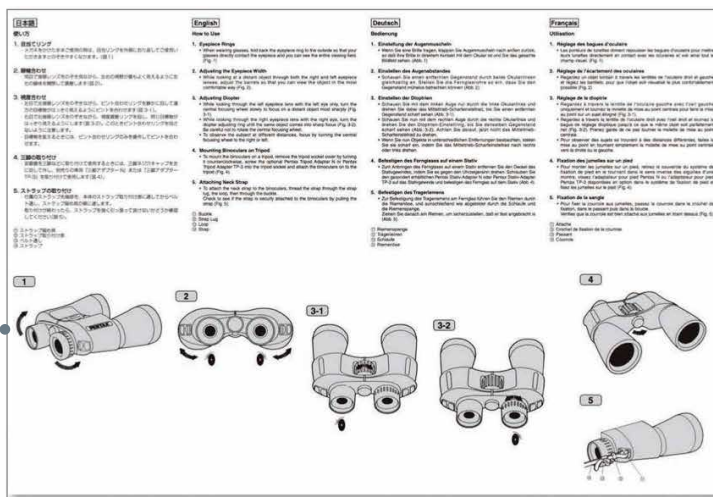
Tripod-mountable

Although you can hold 10x50 binoculars by hand, mounting them on a tripod or monopod will steady the view, especially if you are observing for long periods. The Jupiter 10x50s have a screw socket for a tripod adaptor (not supplied) under a cover at the front of the centre hinge.

FIRST LIGHT

Owner's manual

If you've never used binoculars before, you will appreciate the well-illustrated owner's manual. It is specific to this model and shows in detail how to set your binoculars up for the first time, and provides advice on their use and care.



Protection

Binoculars must be protected against dust on the optics and knocks during transportation. The lightly padded case and simple non-tetherable lens caps are fit for purpose, provided you don't subject them to rough treatment. Like many Pentax binoculars, the neck strap doubles up as the case strap.



► them from accidental contact. The eye relief is specified as 13mm, but the eye lenses are recessed by 3mm into their barrels. As a result, we found that, even with the eye cups folded down, we were unable to see the full field of view when we wore spectacles. This makes them unsuitable for anyone who wears spectacles for moderate to severe astigmatism.

Heading out, we tried the binoculars during the first of several clear nights. Our first target was a crescent Moon, which showed some lovely crisp detail along the terminator in a twilight sky. Once it was dark, we took advantage of Herschel's Garnet Star (Mu Cephei) being well placed and, emulating Sir William himself, we compared its colour to that of nearby stars Alderamin (Alpha Cephei) and Zeta Cephei. The colour rendition of these binoculars made the distinction obvious.

While we were in this region of the sky, we also had a look at Delta Cephei, a close (41 arcseconds of separation) double star, which was cleanly split in the central half of the field of view. We panned down to the Andromeda Galaxy, M31, and also detected its companion M110, although we had to wait until the

fainter M33 had risen above about 30° before we could see it clearly. Nearby, open cluster NGC 752 opened up into a burst of stars, after which we enjoyed visiting many other familiar targets over the next hour.

The Pentax Jupiter 10x50 binoculars are a very well-appointed entry-level instrument for both astronomy and daytime use. We thoroughly enjoyed using them under a starry sky and have no hesitation in recommending them. Provided you don't need to wear spectacles while observing, they are an excellent choice for first-time astro-binocular users. 🌌

VERDICT

Build & design	★★★★★
Ease of use	★★★★★
Features	★★★★★
Field of view	★★★★★
Optics	★★★★★
OVERALL	★★★★★

KIT TO ADD

1. Opticron L-type binocular tripod bracket adaptor (small porro)
2. Astro Essentials microfibre lens cloth
3. Alpine Innovations Bino Bandit eye shield

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Gemma Kerr rounds up the latest astronomical accessories

GEAR



1

1 Svbony telescope accessory kit

Price £49.99 • **Supplier** Rother Valley Optics
www.rothervalleyoptics.co.uk

This seven-piece set is designed to expand your stargazing options without needing to invest in another telescope. It includes a Barlow lens to increase your eyepieces' magnification by 2x, two Plössl eyepieces and three 1.25-inch telescope filters, all bundled in a handy cloth bag.



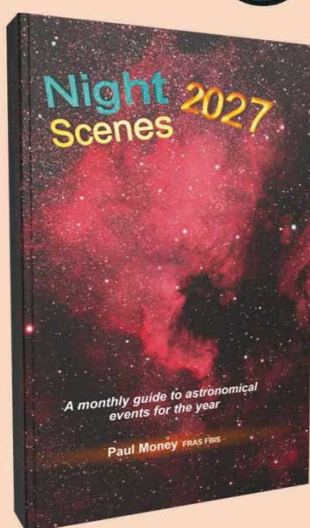
2

2 ESA bomber jacket

Price €149 • **Supplier** ESA • <https://shop.esa.int>

Keep yourself warm on cold stargazing nights with this European Space Agency jacket. Featuring an embroidered ESA patch and print celebrating ESA missions, it's a cool way to show off your love of space. Made from 100 per cent recycled polyester.

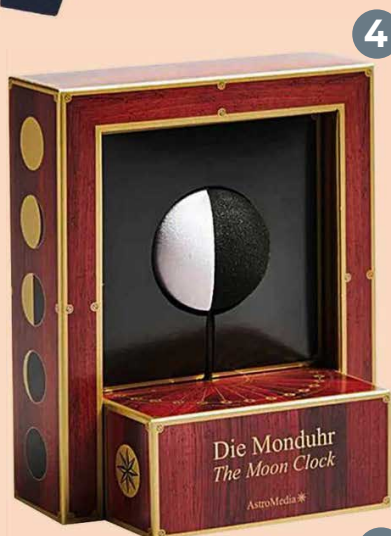
3



3 Nightscenes 2027

Price £15 • **Supplier** Foyles • www.foyles.co.uk

This monthly guide to astronomical events is aimed at stargazers doing naked-eye or binocular astronomy. Guiding you through interesting objects and sights to see in the night sky across 2027, it includes 12 all-sky charts, as well as colour diagrams for special events.



4

4 The Moon Clock

Price £22.99 • **Supplier** Grand Illusions
www.grand-illusions.com

Craft your own clock showing the phases of the Moon. This simple cardboard kit designed for space-lovers has a clever mechanism that rotates in sync with the Moon's real cycle, so you can enjoy its current phase while staying comfy indoors.

5



5 Astro Essentials precision tripod level adjuster

Price £29 • **Supplier** First Light Optics
www.firstlightoptics.com

Screw in this device between your smart telescope and its tripod for easier levelling. The precision controls allow you to adjust the angle by up to 5° to ensure your scope is perfectly level. Compatible with any smart telescope under 15kg that uses a 1/4-inch thread connector, a 3/8-inch version is also available.

6



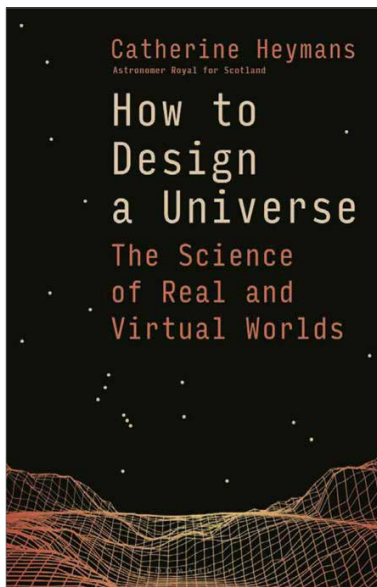
6 ZWO electronic automatic focuser

Price £199 • **Supplier** 365Astronomy
www.365astronomy.com

Temperature changes at night can cause telescopes to drift out of focus, a particular challenge for astrophotographers. This ZWO electronic focuser can be controlled digitally or used with autofocus software, helping to keep images sharp. It has a USB-C connector and is compatible with a range of scopes.

BOOKS

How to Design a Universe: the Science of Real and Virtual Worlds



Catherine Heymans
Bloomsbury Sigma
£20 • HB

Ever wondered whether we're made of quarks or qubits? Back in 1999, this question was on the minds of anyone who'd watched the film *The Matrix*, in which the protagonists discover our 'reality' is in fact a computer simulation.

But rather than try to prove that we're all trapped inside a fake universe, astrophysicist and Astronomer Royal for Scotland Catherine Heymans instead asks: what ingredients are necessary to create a virtual universe? And it's surprising what she's able to cover in only 10 chapters.

How to Design a Universe begins by discussing how light, electricity and magnetism are fundamental to describing

our world. Heymans then moves on to our senses, focusing on the human eye to give us an appreciation of how light and matter interact.

Next she tackles the basics of programming before exploring some tough topics – including quantum theory, gravity and the make-up of the cosmos – and concluding with an intriguing chapter on artificial intelligence and consciousness. We learn of neural networks, theories of consciousness and how AI is reaching a point where we can't always tell what's real and what's not.

It's an interesting concept for a popular science book, and one that had the potential to become complicated. But it's a triumph, due to Heymans' ability to take a mind-boggling idea and make it accessible to anyone. Her personality shines through on every page and it's clearly written with the same understandable style she

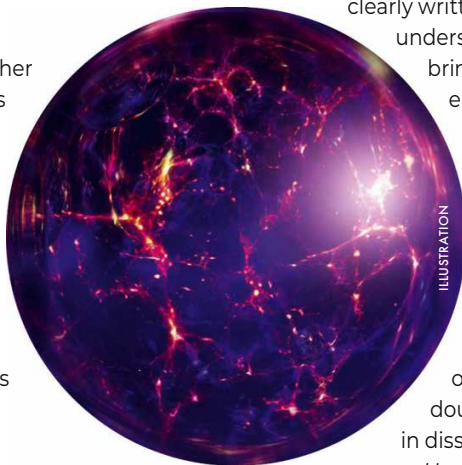
brings to her public engagement work.

Heymans is renowned for her work simulating universes to understand the roles dark matter and dark energy play in shaping our own, so there's no doubting her credentials in dissecting this topic.

How to Design a Universe is an engaging read that combines physics, technology

and our understanding of consciousness to question the nature of reality, and Descartes' dictum, "I think, therefore I am". ★★★★★

Laura Nuttall is a professor of gravitational wave astronomy at the University of Portsmouth



What would it take to create a virtual universe? Heymans digs into the science of reality itself

Interview with the author

Catherine Heymans



What evidence is there that we're in a simulated Universe?

Absolutely none! And annoyingly,

I doubt there ever will be. Sci-fi fans suggest searching for 'the glitch', but if our reality is simulated, it has to be perfect in every way. If it weren't, we'd know about our overlords' existence. However, as our reality appears to be mathematical, we're not able to disprove the hypothesis that this is because a futuristic computer has built both you and all your experiences.

What about a multiverse? Do we have any proof of that?

A range of theories explain how our apparently infinite Universe formed via a period of rapid inflation 13.8 billion years ago. Given the observational evidence for inflation, I'd argue we've inadvertently found indirect evidence for the existence of a multiverse: the mathematical consequence of inflating one universe is almost always the inevitable inflation of a multitude of others. We'll never find conclusive proof the multiverse exists, but that's true of all scientific endeavours. We can never fully prove a theory, only disprove it.

Say we proved we're in a simulation. What would it mean?

Philosopher David Chalmers argues that a virtual reality where you feel free will, love and laughter is as genuine a reality as any real world. I agree. It doesn't matter whether this is all real, so long as we feel real. You might like to give your computational overlord a little wave, though, in the highly unlikely case they exist and are watching!

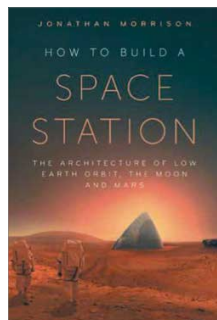
Catherine Heymans is the Astronomer Royal for Scotland

How to Build a Space Station

Jonathan Morrison

Bedford Square

£25 • HB



"A spacecraft," architect Jonathan Morrison asserts, "is not just a machine; it is also a home, an office, a refuge." Yet even after six decades of humans in space, life away from Earth remains

basic and utilitarian. Astronaut Chris Hadfield once likened the International Space Station to a ski-lodge locker room – cluttered and psychologically barren.

In *How to Build a Space Station*, Morrison takes a quirky look at how cutting-edge design is gradually infusing the engineering-dominated world of space construction. He considers how future space stations, Moon bases and Mars settlements must move away

from the structures of yesteryear and become real homes-away-from-home for tomorrow's space travellers.

Living off-Earth has been contemplated for centuries, from Lucian of Samosata's glass-walled lunar cities to Edward Everett Hale's spherical space stations made from bricks, to future plans for transparent domes on Mars or half-buried habitats on the radiation-drenched lunar surface. Morrison discusses the limited role of architectural design in the early space programme, that contributed little besides windows, calming wall colours and soft lighting. Until recently, there was an overarching sense that aesthetic beauty had to take a backseat to dull functionality.

But that mindset is shifting as new actors like SpaceX, Blue Origin, Axiom and others plan to put not tens, but hundreds of people into space. And unlike remote research bases in Antarctica, future habitation on the Moon and Mars will need their own fair share of 21st-century creature comforts.

Designs can and should be different, Morrison writes, with the absence of gravity removing the need for rectangular structures. Buried lava tubes on the Moon could provide shielding for bases against meteoroids and radiation. Innovative interiors designed by Prada and Philippe Starck include padded walls, customised sleeping and communal areas and soft LEDs – a comprehensive rethink of what space stations ought to look and feel like.

Survival in this most inhospitable environment that humanity has ever encountered must always be a baseline requirement for any off-Earth habitat. But with a sizeable percentage of future space travellers likely to include ordinary people and tourists, Morrison shows human health, performance, wellbeing and happiness must take centre stage.

★★★★★

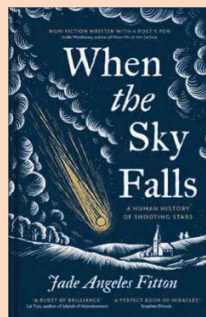
Ben Evans is the author of several books on spaceflight

When the Sky Falls

Jade Angeles Fitton

Batsford

£15.99 • HB



Comets, meteors, meteorites and asteroids have long fascinated those living under dark skies. Unlike other books on this topic, *When the Sky Falls* is not about astronomy, what

these objects are or how they differ from one another. Rather, it's a collection of stories from different places and times, each featuring a comet, meteor, meteorite or asteroid, which the author collectively describes as 'shooting stars'.

The work is broken up into four main parts exploring 'shooting stars' in art and culture, as material objects, in superstition and throughout history.

Each section is divided into between seven and 11 standalone stories. The introduction, conclusion and epilogue make clear the book's broader aim: to encourage readers to look up at the night sky and feel empathy and connection with the superstitions and folklore of our ancestors. Fitton retells stories ranging from the Gibeon meteorite that landed in Namibia in prehistoric times to the various sightings of Halley's Comet over the decades, all recounted in the journalist and poet's distinctive voice.

The author works hard to include stories from diverse cultures, including tales from every continent, spanning thousands of years. Through them, she highlights the beauty and wonder that darker skies would allow us to appreciate, just as generations did before us.

Any plea for more light-pollution-free spaces is certainly something to be celebrated. Today, the number of people living under truly dark skies is fewer than ever, and appropriately the book closes

with a list of dark-sky zones around the world for readers interested and able to travel to seek out locations where the view of the night sky is particularly spectacular.

I would have liked to have seen more connections drawn between the diverse stories, perhaps detailing how they have travelled and altered between places and across generations. I also found the frequent shifts between comets, meteors and meteorites a little confusing, making it harder to spot common ground and make links.

However, this is not a traditional astronomy book. Fitton's focus is folklore rather than scientific or historic explanation, and readers who share that interest will find a wide-ranging collection of tales drawn from cultures across time and around the globe.

★★★★☆

Emily Winterburn is a science historian and author

Anthony Chambers listens in to French astronaut Sophie Adenot on the ISS

Q&A WITH AN ESA SPACEWALKER IN ORBIT

What's it really like to walk in space? We hear from the French astronaut who's spent over 19 hours fixing the International Space Station this year

Is there a difference between seeing Earth from the Cupola of the ISS and seeing it beneath your feet, as you did during your spacewalks?

The landscape we see is ultimately the same. If you get very close to the window, it's the same view. But it's really the feeling of security you have inside the ISS that you don't have outside. When you're in a car and you open the window and see a cliff, you can see a beautiful landscape, but you feel safe because you're in the car. By contrast, during a spacewalk, it's like opening the door and standing there with just your feet at the edge of the cliff. The feeling is completely different. And that landscape becomes something that really takes your breath away. It's incredibly impressive and beautiful, but also intimidating.

You've done three spacewalks in two weeks. Given the physical effort involved, did you have to make any specific adjustments to your routine?

The key is making sure that your physiology and your body can keep up. A spacewalk is a colossal physical effort. When you know you have to do spacewalks seven days apart – three EVAs [extravehicular activities, or spacewalks] in 15 days – yes, recovery is the key. That means adjusting your nutrition to make sure your body has what it needs to recover. You also have to make sure you're sleeping well. And then you adjust your physical exercise. For me, particularly between EVA number two and number three, I did much less upper-body work as my muscles were already very sore. I only did exercises for my lower body. And it paid off, because as a result I was really fit for yesterday's mission.

Has the time you've spent in space changed your perception of humanity and planet Earth?

When you're on a spacewalk, you see Earth as incredibly beautiful and impressive. You think: this planet Earth is the one that protects us all and connects us all, regardless of which continent we come from, whatever our native language, whatever our past.



▲ Adenot, the first French woman to perform an EVA, has so far replaced a failed antenna, repaired a docking reflector and upgraded the ISS's cameras

We're all on this same planet, and it's this planet that provides us with all our resources. Yesterday, at the farthest forward point of the space station, repairing the reflector, all I had in front of me was Earth. And at that moment, you feel very small, but at the same time so connected to every human being on Earth.

The end of your mission aboard the ISS is approaching. Have you

had time to do everything you planned to do?

The problem with me is that I have a very vivid imagination. Leave me another six months and you'll still have plenty of things to do that weren't originally planned. Broadly speaking, we're reaching a point where most of the objectives have been accomplished. There are still a few weeks left, and I think we'll even go beyond the original objectives.

What are the differences in how the first and third EVAs felt? Do you become a little blasé about it?

You can never become blasé during a spacewalk. The three EVAs were all very different, so the concentration was intense and the stakes were also quite high. So definitely not blasé – very focused.

The advantage of the third is that you know what to expect. You don't have the pressure of the unknown. The first is really difficult; I think that's true for every astronaut. It's this huge leap into the unknown when you stick your head out of the airlock and see the enormous Earth beneath you. By the second and third, you gain confidence in yourself that yes, you can accomplish a mission, even in a very hostile environment.

You haven't even returned to Earth yet, but do you know when you'll be going back to the ISS?

Well, I'm a huge fan of space exploration, so any space journey you mention will always put a huge smile on my face. But I'm also aware that there is a time for recovery and a time for others as well, because there are many European astronauts, so everyone gets their turn. If someone tells me, "Go again," then I'll go again. With great pleasure. 🌍



Sophie Adenot is a French astronaut, engineer and helicopter pilot currently stationed aboard the International Space Station



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THE SOUTHERN HEMISPHERE



With Glenn Dawes

This month, spend evenings lying down to soak up the sky, and mornings getting up for meteors!

When to use this chart

1 Nov 00:00 AEDT (31 Oct, 13:00 UT)

15 Nov 23:00 AEDT (12:00 UT)

30 Nov 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

NOVEMBER HIGHLIGHTS

The Leonids are one of the better-known meteor showers. Although best for Northern Hemisphere observers, good displays have been seen from down under, showing persistent, bright fireballs. Active around 6–30 November, maximum is expected on the 18th. The morning will be Moon-free, which suits the Leonids which are best seen before dawn, when their radiant in Leo is low in the northeast. Peak rates can reach 15 meteors per hour, but 5–6 might be more realistic.

STARS AND CONSTELLATIONS

November offers a unique view of the heavens. Escape light-polluted skies and head somewhere with low horizons. Whichever way you look, the Milky Way's glow sits on the horizon, forming a near-unbroken ring around you. Lie back and soak in the Southern Universe, where breathtaking nebulae and star clusters have given way to faint stars and galaxies. You can enjoy this special view at other times of year too, whenever the faint glow of the Andromeda Galaxy lies due north.

THE PLANETS

Evenings begins with Neptune and Saturn well placed, crossing the meridian. Uranus rises around sunset, culminating just after midnight. The early hours also find Jupiter and Mars rising, though best observed in the predawn.

Mars makes its closest approach to Jupiter (1.2°) on 17th. Venus returns to the morning, rising around the start of dawn mid-month. Mercury follows, reaching maximum elongation in later November, but sadly low in the eastern dawn glow.

DEEP-SKY OBJECTS

The northern constellation of Cetus, the Whale has a faint but distinctive asterism of six stars arranged in a pentagon. The brightest, in the southeast corner, is the binocular double Alpha (α) Ceti (RA 03h 02.3m, dec. -04° 05'). Its orange mag. +2.5 primary makes a wonderful colour contrast with its fainter (mag. +5.6) blue companion, 16 arcminutes north.

Speaking of contrasts, move 6° southwest to two galaxies. The mag. +10.5 edge-on spiral NGC 1055 (RA 02h 41.7m, dec. +00° 26') appears as a faint 4-arcminute streak, forming an equilateral triangle with two nearby seventh-magnitude stars. In the same low-power field (0.5° southeast) lies the impressive ninth-magnitude elliptical M77, showing an obvious bright core.

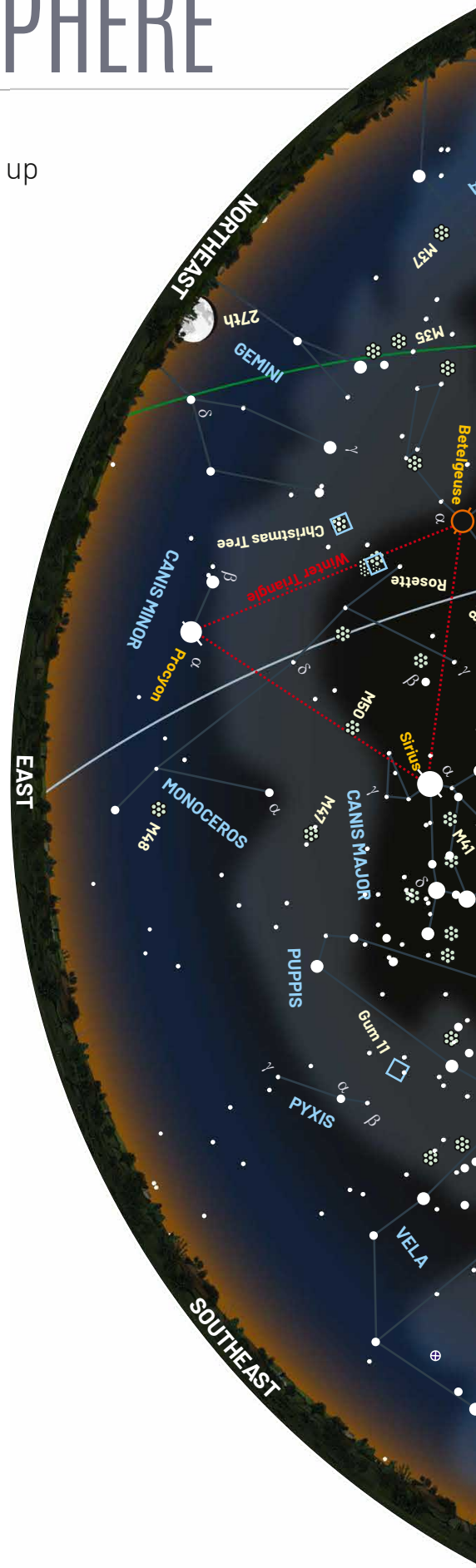


Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK

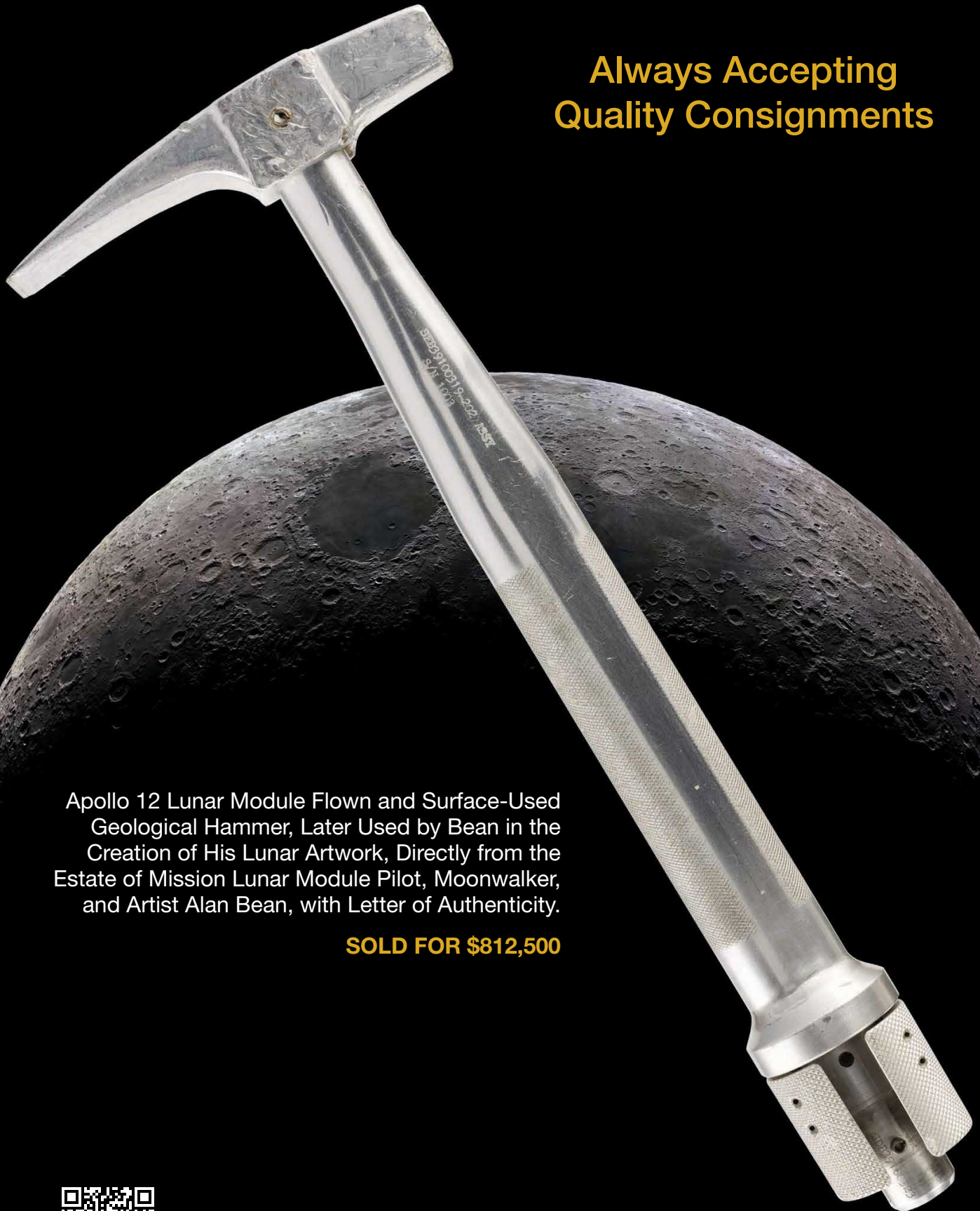
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

- STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
 - MAG. +1
 - MAG. +2
 - MAG. +3
 - MAG. +4 & FAINTER

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